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CIA/OER/S-06688-74

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S-6688

MICRO ONLY

18 December 1974

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MEMORANDUM FOR: [redacted]
Executive Secretary
Intelligence Advisory Group on Exchanges

SUBJECT : Soviet State of the Art in Selected Energy Areas

REFERENCE : Memorandum to You, From Oswald H. Ganley, Department of State, Subject: Request for Information on Energy R&D Topics, dated 18 November 1974

Attached in response to reference are comments, lists of Soviet institutes and source materials, and translations of selected articles pertaining to topics mentioned in Appendix 5a and Appendix 5b of the "Record of the First Meeting of the US-USSR Joint Committee on Cooperation in the Field of Energy". As OSI is addressing the R&D aspects of the topics, we have limited our response to cases on which we believed we could make some useful contribution concerning the state of actual industrial application. An advance copy of the attached materials has been given informally to Mark Alexander, USAEC/ISA, who originally requested them -- apparently through several channels.

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APPENDIX 5a

A. Design & Operation of Thermal and Hydroelectric Power Stations

ELECTRIC POWER AND RELATED EQUIPMENT

UDC 69(063):621.22

NEWEST DEVELOPMENTS, PLANS, CONCEPTS IN HYDROELECTRIC CONSTRUCTION OUTLINED

/Report on meeting by V. Kh. Gol'tsman, Candidate of Technical Sciences: "Scientific-Technical Progress in Hydroelectric Construction"; Moscow, Gidrotekhnicheskoye Stroitel'stvo, Russian, No 6, June 1972, pp 54-59/

In December 1971 a meeting of the technical and scientific councils of the NIS /Scientific Research Department/ for Problems of Scientific-Technical Development in the Field of Water Power and Hydraulic Structures was convened at the All-Union Planning, Surveying, and Scientific Research Institute imeni S. Ya. Zhuk (Gidroproyekt).[1]

In an opening address the institute's chief engineer, I. L. Sapir, pointed out the need to determine the basic goals of scientific research and design in the field of water power. Twenty-four reports were presented and discussed. This report outlines the most interesting speeches since it is not possible to present them here in their entirety. /2/

The report of candidate of technical sciences B. L. Erlekhman was devoted to research results in the field of long-term scientific and technical prognostications concerning the development of domestic water power up to the year 2000. The enormous economic potential of the USSR's hydraulic power resources has barely begun to be exploited and no more than 20 percent will be in use by 1980.

The growth of electric power production in our country will be accompanied by a rapid increase in the variable loads and stresses on the fuel-power balance in conjunction with a decrease in the maneuverability

1. According to the materials of the enlarged session of the Gidroproyekt technical council.

2. Readers desiring more detailed, specific material are referred to the Gidroproyekt Institute's technical section (Moscow, A-80, Volokolamskoye Highway, 2).

of thermal electric power stations (TES) and nuclear power stations (AES). Up to two-thirds of all the work-force increase would have to be employed in electric power production by the end of the century in order to maintain the current indicators of labor productivity and fuel expenditures.

The problem of sharply increasing the labor productivity level can be resolved only by rapid technical progress in thermal and nuclear power production combined with the maximum use of hydraulic resources that nature is constantly replacing. The development of water power is one of the manifestations of technical progress in the nation's power system and it has a favorable influence on water conservation, ecology, and social conditions.

The developmental rate of water power depends on the current level of financing. A 5-7 percent increase in this level is anticipated during the five-year plan and this will probably increase the hydroelectric power output to 600 billion kilowatt-hours by the year 2000. However, if the rate of hydroelectric construction is close to the average capital investment growth rate in the national economy (30-35 percent during the five-year plan), this figure may be larger.

The norms and criteria of economic calculations greatly influence the development of this sector. The future retention of understated data concerning fuel expenditures, high profit norms (12 percent on supplementary expenditures), and credit payments (8 percent) will needlessly limit the construction of a number of new hydroelectric power stations (GES). Considering the increased reductions in living labor (700-900 percent compared with TESs and the fuel base) and the calculations concerning accumulation norms which are no higher than those used abroad, the expanded use of hydraulic power resources is economically justified.

Candidate of technical sciences B. L. Baburin reported on the trends in the development of methods of substantiating the efficiency of hydroelectric power construction. Hydroelectric power is characterized by high labor productivity and varied national economic effects. The construction and operation of GESs during the 1951-1968 period required 50 percent less labor expenditures than the replacement of the GES construction program by a heat and electric power station construction program (650 million man-days compared to 1.3 billion man-days on a version of a TES together with a fuel base). The living labor conservation factor will play an important role in the future development of our nation's economics.

An analysis of the efficiency of hydroelectric construction shows the profitability of GES construction. The GES profits for the 1956-1968 period comprise 45 percent of the profits from the operation of all electric power stations while the GES production accounted for only 18 percent of the total production. A TES earns 19 kopecks of profit per ruble of production while a GES earns 73 kopecks, almost four times more. All this is still not fully reflected in economic computation methods. Thus, in the future it will be necessary most of all to focus attention on the calculation

of living-labor expenditures, the higher labor productivity of GESs compared to TESs, and the influence of hydraulic construction on all new regions and on the cost of land used for water reservoirs, taking into consideration the optimum use of both land and water resources.

A. G. Yakobson reported on the same topic and offered examples to confirm that the implementation of a method of determining the economic efficiency of GESs would make it possible to repay construction costs over longer periods, not considering the fact that outside those periods the GESs would produce very inexpensive electric power over a period of years. The fact that building many of the largest GESs entails the pioneering development of remote areas is not taken into consideration. It would be correct to view this type of expenditure included in a GES's estimated costs as state expenditures related to the entire complex of future industrial construction.

The expenditures that are actually not made by the builders but that are automatically included in the state budget are included in the GES cost estimates. Such expenses in the motor vehicle transportation field are twice as high as the expenditures actually borne by the builders. The difference between them is transferred into the budget. The situation is similar for electric power expenditures. Very inexpensive power is produced after the commissioning of a project's first unit, but its cost is calculated according to an increased schedule and the difference is transferred into the budget. In the cases mentioned there have been unnecessary expenditures included in the estimates that have unjustifiably decreased the construction efficiency. The elimination of such expenditures from GES construction cost estimates in determining their efficiency would facilitate the creation of more accurate pictures of capital investment use.

Doctor of technical sciences V. M. Lyatkhor reported on the Gidroproyekt operations in the area of seismic stability and structural dynamics. Two trends are being developed: the first involves predicting the intensity of seismic activity with regard for a region's geological structure, the mechanical characteristics of materials, and the influence of water reservoirs under construction. The second trend is the building of models and the calculation of stresses and strains on the structures during seismic activities. This has entailed the classification of regions according to geological-tectonic and mechanical indications that make it possible to select similar ground-movement accelerograms that offer the first indications of possible activity. Considering the fact that this does not allow a sufficiently precise evalution of the parameters of seismic activity, development work has begun on a likely method of describing earthquakes and their consequences according to data concerning the region's deep geological structure that has been obtained by geophysical methods. This will make it possible to build up a collection of possible accelerations, speeds, or displacements and evaluate one or another of the activities' parameters. Still more refined methods of calculation and model utilization are being developed that are immediately dependent on an analysis of wave action in foundations and structures. The calculation of actual conditions of structural behavior are revealing large reserves of carrying capacity and can offer substantial economic benefits.

Important advances have been noted in the area of investigating and calculating the seismic stability of dams made of local materials and taking into consideration the influence of interstitial liquid. The overall approach to the dynamic calculation of earthen dams is based on the following situations.

A. A dam's stress condition is made up of a static and a dynamic component. The first must be obtained by calculating the earth's strain and rheological characteristics and the second can be calculated and modelled on the basis of equations that have been linearized relative to a statically stressed condition.

B. The dynamic effect can create momentary prelimiting or postlimiting (dopredel'nyye ili zapredel'nyye) states and, in addition, the remaining deformations are the results of the accumulated deformational flow during the postlimiting states.

The overall task consists of evaluating the earthen dams' final deformations during the given activity. The possibility of reducing the water and gas-saturated material of earthen dams to a monophase elastic medium with generalized elastic and dissipative constants is a decisive factor.

Doctor of technical sciences N. A. Malyshchev outlined the development of domestic dam construction. Alluvial dams had been built on lowland rivers only in the USSR until we used them on the Nile and Euphrates rivers; more such dams will be built in the future. The simplest equipment will be used to build them and will have to be renewed and developed along with the alluvial technology.

In the area of dam construction from local materials we are experiencing shortcomings in the special equipment used to transport and place the earth under construction-site conditions. However, not much research is being done on learning how the dams' cores will turn out when they are built by using explosives for earth moving and we do not agree that such dams should be built. A program of research and design should be planned for both trends.

Dredges are now being successfully used to make excavations in cohesive soils. In the future the high-production equipment for alluvium that we have created and introduced can be used to build dams from local materials by hydraulic transportation of crushed materials such as limestone. Under conditions such as are found in the north when it is difficult and expensive to work during the winter it is possible to construct large dams. This method must be developed, researched, and then confidently introduced. It is necessary to develop dam designs for the north that take into consideration the difficulty of outdoor work.

The highest of the dams that have been built (besides the Nurek dam that is under construction) are made of concrete. In the future they

will be widely used, but for the present they must be developed further. The modern gravity dams have lost their simplicity because of their saturation with various water-drainage openings, the zoning (zonirovaniye) of concrete, and the new high frost-resisting and other requirements for concrete. The simplicity of this type of dam should be recovered and use made of cheaper cements and admixtures as well as coverings to shield the concrete from the activity of destructive factors. The dams' degree of economy should be sought not so much in the reduction of cross-section or decrease in concrete volumes as in the use of the cheapest materials and production methods.

We are still unsuccessful in building the most economical and advantageous arch dams that best exploit natural conditions because of faulty engineering-geological explorations. The incorrect evaluation of geological conditions at the start of the design phase later leads to changes in the type of dam and considerable cost increases. At present there are no technical difficulties in building multiarch and counterfort dams; these types have proven themselves in Scandinavia.

In dam construction as a whole, it is necessary to increase the level of economic work, eliminate errors in selecting dam types, and master all the aspects of pricing. For example, there is no need to build high dams in areas where the flow is fully regulated as was proposed for the Kurpsayskaya GES 40 kilometers below the Toktogul reservoir. Under these conditions, having lain out an overfall on two levels, it is possible to cut the concrete volume in half and lower the amount of transport work considerably. Economic requirements demand objective examinations of the conditions at every water facility.

Candidate in technical sciences V. S. Panfilov noted that the most important problems still include obtaining strong rock sides and foundations, ensuring monolithic concrete placement, developing winterproof and durable concrete, voids in concrete caused by the rapid movement of water through it, the extent of seismic activity at the dams and adjacent rock mountains, limited bearing capacity, and the characteristics of structural failure.

L. D. Lentyayev examined the problems of hydraulics and the hydrodynamics of high-pressure water outlets and noted that the existing functions for calculating the linking of races according to the system for ejecting the flow from the outlet (tramplin) nozzle are obviously necessary in serious definitions inasmuch as the data concerning full-scale observations do not confirm the recommendations for calculating the distance of cross-brace deflection (otbros strun) or for the degree of flow widening. Definite difficulties are present in calculations and the laboratory determination of watercourse erosion while the main difficulty lies in building a model of a crumbling mountain of rock.

Attention must be focussed on the need to develop functions for the quantitative evaluation of the erosion process that occurs in conjunction with cavitation, the scouring of watercourses, and the interaction of structural elements with the flow.

R. R. Tizdol' reported that our successes in the field of studying the mechanics of different types of rock will facilitate the sure and efficient design and construction of high dams on rock foundations. Modern methods of field and laboratory research and full-scale observations of rock foundations, methods of calculating the strength and stresses in rock foundations and supports used for dams, calculations to determine the stability of side slopes, and methods of sealing large rifts have been developed and put into practice. None the less, there are still many unresolved problems that require theoretical and experimental research.

A report from the Lengidroproyekt /possibly Leningrad Planning, Surveying, and Scientific Research Institute/ engineers that was read by N. L. Triger noted our limited experience with the problems of hydraulic construction in permafrost areas. However, the future construction of special-purpose hydroelectric power stations on the northern rivers will require the most serious preparation and the completion of many tasks that are presently being studied very little.

One important characteristic of some types of permafrost is the presence of internal ice that has a great influence on the long-term strength of a foundation. The most profound modifications are required for the construction and operation of dams and their reservoirs under permafrost conditions. These modifications are needed because of the penetration of water into the earth and the large quantities of relative warmth that the water carries with it. In this regard an urgent need has arisen for the development of a method for the engineering-geological investigation of these soils.

The weakest link in the construction of dams from local materials in permafrost areas is connecting them with the foundation, banks, and concrete structures. One of the reasons for the damage to many dams is the filtration arising in the zones where the dam abuts the banks.

The inability to allow for the deterioration of old permafrost in the zone where the dams and reservoirs come into contact with it makes the design work very difficult. In rock-fill dams there have been cases when ice has formed in the down-stream section causing a dangerous heaving condition there and a decrease in strength.

Many difficulties have been encountered in the construction of water outlets that are unsatisfactorily employed on the construction of dams because of the unknown effects of the warm water on the permafrost where these two factors come into contact. One satisfactory solution is the construction of water outlets on piling with breastworks (pazukhi) to cool the foundation which makes it possible to increase the foundation's resistance to filtration and deterioration.

The designs for permafrost areas must cope with the problem of building antifiltration barriers in the soils subject to filtration. A complex situation develops when frozen and thawed areas come into contact

within the core of earth-fill dams and the interaction has still not been studied. In addition, measures have not been developed that can warn of the core or screen material's loss of plasticity when subjected to below-freezing temperatures.

It is also necessary to study the settling of a rock mountain's permafrost as a result of thawing and develop methods of predicting and calculating it.

The task of creating the basic equipment needed to install and construct machines that will function dependably at very low temperatures is especially important.

The problems of work organization and production are decisively important for further construction progress under the severe conditions of the north and in the permafrost regions.

M. F. Krasil'nikov reported on the trends in developing water-power equipment for GESs and pumped storage electric power plants (GAES). The following trends are to be found both in the USSR and abroad in the area of hydraulic machine building: higher unit capacities, the appearance of high-speed hydraulic turbines in the field of higher pressure heads, the optimization of the equipment's power and cavitation qualities, the use of new types of hydraulic units (reversible, capsule, with diagonal turbines, with high-voltage generators, and others), quality improvement, and increased dependability and operating life for hydraulic units.

A comparison of modern hydraulic machine building in the USSR and abroad reveals that our nation produces variable-pitch and Francis-type turbines with the largest dimensions and highest individual capacities. However, we lag behind the best foreign firms in maximum pressure heads for all types of turbines, in quality sometimes, in processing finished and production precision, and in the efficiency-factor level of variable-pitch and Francis-type turbines.

Work has begun in the USSR on the creation of diagonal variable-pitch hydraulic turbines and our specialists have outstripped foreign researchers in developing models. We also have practically no experience in the development and production of large reversible hydraulic machines.

Our machine builders face two main tasks. The first involves higher quality, increasing the dependability and lowering the production costs of water-power and electrical-engineering equipment, and expanding unit deliveries. The second consists of creating and introducing new types of equipment, high-pressure gates, and electrical-engineering and mechanical equipment for the severe northern conditions and areas of considerable seismic activity.

K. K. Kuz'min presented a report on the development of grouping and design decisions for GESs. In our nation, as abroad, hydraulic power stations are quite often combined with water-outlet structures. Beginning

in the 1940s, the separate groups of channelized (ruslovyye) GESs were almost completely based on domestic construction practice. This is explained by the fact that these GESs were built on large rivers where a very long spillway front would have led to high hydraulic unit costs. Moreover, two types of combinations were defined: with pressure-head water outlets and with spillways. The use of the first type facilitated a decrease of up to 30 percent in the spillway front and this figure increased to 50 percent with the second. A GES built on, or adjacent to, a dam in a narrow canyon could get rid of the exhaust water expediently by routing it through the roof of the machinery building.

The expediency of combined groupings when used in conjunction with draw-off facilities with short draw-offs (like the Aswan design) has also been confirmed. Besides this, the broad application of underground GESs in conjunction with high dams should be recommended for the further refinement of groupings. The same can be said for the construction of the forks for the mixing structures' pipes inside the mountain, thus exploiting the effect of rock's elastic resistance; the use of riverbank mixing groups with feeder tunnels for pressure heads ranging from 40-80 meters; the use of ferroconcrete spiral chambers with T-shaped cross sections up to the calculated pressures of 100-120 meters and with round spirals in the mixing assembly for large-capacity units with high pressure heads; and the other decisions that facilitate the more complete utilization of structural volumes and materials.

O. I. Zeyegofer told of the recently-begun construction of spiral chambers made up of composite ferroconcrete structures. These structures offer the only possibility of overcoming the exceptional technical difficulties encountered in developing a completely-metal spiral for large units with high pressure heads. The introduction of a convoluted rod-shaped shell reinforced with a surrounding coating of concrete helped to resolve this problem. This design has been used for the spiral chambers of the Charvak and Nurek GESs and was developed over many years of scientific research and design work.

Ya. N. Vetukhnovskiy presented a report concerning the mechanical equipment used for hydraulic units that drew attention to the efforts that have been directed toward lowering costs and increasing dependability. The construction of structures on large rivers has required the creation of special-sized gates. For example, a gate with a 110-meter opening and two gate mechanisms with lifting capacities of 900 tons each is being installed at the Volga delta and a segmented gate 40 meters wide with a height of 14 meters is in use at the Vilyuysk GES. Such gates being designed feature a yield-point safety factor of 1.50 in the USSR, 1.82 in the USA, and 2.00 in the FRG.

We have built gates for an outlet of 25 square meters and a pressure head of 98 meters (Krasnoyarsk), 30 square meters and an 85-meter pressure head (Charvak), a gate with an area of 30 square meters is being installed for a pressure head of 110 meters (Nurek), and a gate of 20 square

motors is being designed for a 220-meter pressure head (Inguri river). New types of closure assemblies have been created for pressure heads up to 200 meters.

In creating the mechanical equipment for high pressure heads the problems of corrosion and cavitation become especially important. The plants producing this new equipment must have everything needed for the precision machining, welding, and annealing of the large sections. At the same time it is necessary to adjust the output of sheet and section-shaped rolled steel with a high yield point that has been welded efficiently and is able to function at temperatures ranging down to -60°C.

V. F. Balakirev's speech noted that the results of theoretical and full-size research into the stability of capsule hydraulic units have confirmed the presence of sufficient stability and the possibility of safely installing them in GES. The beginning of experimental-industrial operation of an experimental high-voltage generator at the Skhodnya GES must be considered a great achievement because it has permitted us to proceed toward the technical design of a 103,000 kilowatt, 165 kilovolt generator for the Dnepro-GES-II. Work is proceeding on the design of 220 kilovolt generators.

Special attention should be focussed on the problems involved in the further optimization of automatic operation and control systems for GESs. The number of operational and administrative personnel at GESs is still extremely large. The optimization of a control system for GESs must be accomplished by developing automatic control systems (ASU). A similar experimental ASU is already being created at the Kiev GES-GAES and the Kanev GES. The UM1-NKh computer has been used as the basis for the complete control and regulation system recently introduced at the Votkinsk GES. There are plans to change over to semiconductor units in the automation of GESs because of the contactless logic elements that can replace the older relay-contact elements.

L. B. Sheynman reported on future trends in the design of water- and pressure-accumulator installations. Considering the increased inequality between electric load curves and the simultaneous decrease in capacity flexibility on the part of power-system equipment, the near future will see the capacity of the water-accumulator power stations in the European part of the USSR increased to 10 million kilowatts. In addition, savings will amount to 500,000-600,000 tons of comparison fuel per 1 million kilowatts of the GAESs' designed capacity. The report listed the methods employed to store electric power: hydraulic method at the usual type of GAES and those with subsurface reservoirs and pneumatic at gas-turbine or air-turbine installations. Various details of these systems are currently being studied. The usual type of GAES requires improved grouping and design decisions, equipment, and construction methods. The GAESs with underground reservoirs require the development of construction equipment and the completion of careful research and design work. In regard to the air-storing installations that accumulate the compressed air needed for the operation of gas and turbine installations, line diagrams must be drawn up and basic developmental trends defined.

More work must be done to increase the capacities of individual units; increase the pressure heads of reversible units to 600 meters; and use GES reservoirs, TES /thermal electric power stations/ cooling ponds, and natural bodies of water for GAES basins. Additional efforts are needed in providing conditions for the installation of reversible units at the GESs being designed with high pressure heads, creating GAESs with underground reservoirs, and developing research efforts at the operational water-accumulator power stations.

In the field of developing air-accumulator installations it is necessary to regulate the work, include it among the most important projects of the State Committee for Science and Technology, secure the needed financing, and attract the necessary plants and scientific-research organizations.

R. I. Bobrov read T. P. Dotsenko's report on the very efficient application of combined layouts at the large bodies of water associated with GESs and TESs and offered examples of these successful combinations. The combining at one place or nearby places of GRESs /state regional electric power station/ and AESs /nuclear electric power plants/ with GESs and GAESs in order to combine their use of water facilitates the simultaneous use, relative to some functions, of a number of important and expensive structures (for example, the reservoir of a GAES can be also used as a cooling-pond). Such an arrangement also makes possible substantial savings of the scarce water resources needed for the operation of large electric machines and the equally-scarce land resources for the placement of basic structures, reservoirs, roads, power-transmission lines, and power-control projects. A few regions have already been examined where such a combination could lead to substantial decreases in capital investments.

I. I. Vaysblat reported on the progress in concrete operations. There are plans to place approximately 50 million cubic meters of concrete for hydraulic installations.

The progress in concrete work is divided into two stages. The first stage involves the development and implementation of the already-available progressive decisions for concrete projects (the Toktogul, Chirkeyskaya, and Ust'-Ilimsk GESs) in cooperation with the appropriate concrete plants in order to achieve a productivity level approaching that of similar concrete plants in the USA. Also of concern are the continuous-operation concrete plants under construction at the Inguri and Sayanskaya GESs; the replacing of the ash-bearing part of cement; the industrial creation and production of special transport systems — concrete-carrying motor trucks of various capacities; the broad introduction of a completely mechanized Toktogul-method of layered concrete placement and cable-crane construction system that facilitates the placement of 4-7 cubic meters of concrete per hour each day; cantilever (konsol'nyye) and reinforced metal and wood-metal forms; the Toktogul, Chirkeyskaya, and Inguri methods of intrablock work organization; and others.

The second stage involves the further optimized mechanization of concrete operations; the resolution of problems encountered in further

productivity increases at concrete operations, the shortening of transport lines, the simplification of construction designs, the subdivision of large concrete operations, and others; the further refinement of transportation facilities and, on this basis, increasing concrete transportation distances without losses of the concrete's quality; the creation and introduction of new construction methods, including constant-flow methods; new self-supporting forms made of new materials; new methods of mechanizing intra-block operations; the creation of new machines and mechanisms for concrete work; and so on.

A. G. Oskolkov reported on work in the field of increasing the efficiency of materials for hydrotechnical construction. We are presently gaining broad capacities in the production of hydrotechnical concretes of the required quality. New varieties of concrete have appeared such as poured concretes (including low-cement concretes with ash-bearing admixtures), low-gravel concretes, and concretes with controllable hardening periods. The man-made large aggregate Keramlit has been created from the burning of clay and permits considerable decreases in the amount of cement used in high-strength concrete with a volumetric weight ranging up to 2.3 tons per cubic meter.

The fulfilment of the requirements for hydrotechnical concrete, including concretes for high dams, is impossible without quality controls at all the stages of production, placing, and curing, up to the time when the structure is subjected to operational loads.

The use of polymeric materials in hydrotechnical construction is particularly interesting. It is used for water and heat insulation purposes, as an anticavitation and anticorrosion protective layer, and as elements in such things as antifiltration devices and seals for strain joints. If they are to be more widely used, polymeric materials must be more actively employed in designs and their economic efficiency evaluated, the means must be developed and created that will lead to the mechanization of operations with the help of specialized organizations, and the most acceptable selection of polymeric materials must be furnished to the industrial enterprises.

Candidate of technical sciences V. I. Vutsel' reported on the scientific research work concerning the construction of dams from local materials. Dams made of local materials constitute 90 percent of all the dams in the world and the highest one under construction is the 300-meter Nurek dam. The designing of many important earthen dams has posed a number of complex new problems in conjunction with the introduction of new types of laboratory and field investigations of soil and stone materials under high pressures. This has required the creation of new equipment.

In carrying out the scientific research work the main trends in its further development were determined and formulated. These include the following.

A. The fulfilment of general experimental research for the development of basic methods of determining the stability characteristics of

materials used in lateral prisms. This is needed to correlate the results of subjective methods employing a variety of laboratory equipment.

B. The completion of laboratory and field work in order to evaluate objectively the differing results produced by the methods of computing dam side-slope stability. In addition, the development of methodical directions and programs for computers is also needed.

C. The development of research methods for the stress states, distortions, and formation of fissures in earthen dams and the core of stone-earth dams with regard for their spatial functions and the variability of the materials' mechanical characteristics, the consolidation processes, and the creep in constructing high dams.

D. Development of a method of predicting settlement of a dam's crown during seismic activity when separate lateral sections may be shifted to more stable positions without a great decrease in the dam's operational qualities.

E. The development and creation of a fleet of special machines for the construction of high dams from local materials in mountainous areas because the lack of these machines strongly affects the rates and quality of the dams being built.

V. G. Lebedev told about the basic trends of scientific-technical progress in the design and construction of underground hydrotechnical structures and noted the constantly-growing volume of underground work in hydrotechnical construction. An analysis of general information concerning advanced underground work experience and future scientific endeavors in this field has made it possible to determine the basic trends of scientific-technical progress in underground hydrotechnical construction.

The first trend is the optimization of the traditional blasthole method of underground excavation and the construction of regular concrete or ferroconcrete structures, areas having large untapped potentials. In the first phase of optimizing this capability by developing the technology's optimum parameters and increasing construction's organizational level, the speed of excavation can be quickly increased at least 100 percent, labor expenditures can be reduced 50 percent, and the cost of underground construction can be cut 15-20 percent. In the second phase the average speed of excavating hydrotechnical tunnels can be increased 150-200 meters per month with decreases of 25-35 percent in labor expenditures and operational costs as a result of raising the level and range of mechanization by creating and introducing more advanced equipment.

The second trend of scientific-technical progress is the revision and introduction of new tunnel-excavation technology by using the combine method (without blasthole drilling) with complete mechanization of all the processes. At present two types of tunnel combines are being created according to Gidroproyekt's technical-economic requirements. The first features working parts with a selective action for excavating tunnels with

cross sections of 10-40 square meters in rock with a compression breaking point up to 800 kilograms per square centimeters. The second has a cutting assembly for excavating round tunnels with a cross section of 22-30 square meters in rock with a compression breaking point up to 1,200 kilograms per square centimeter. The introduction of the new technology and combines will make it possible to excavate hydrotechnical tunnels at speeds up to 300-500 meters of finished tunnel per month. Moreover, labor expenditures will be cut in half and costs will decrease one-third.

The third trend of scientific-technical progress must be considered the scientific research and experimental work on new ways of removing rock without explosives or mechanical force. The longest-range schemes for this application ~~on~~ underground hydrotechnical construction involve an ultrahigh frequency method that employs an alternating superhigh frequency magnetic field that acts on the rock; the other method uses the beam of a laser.

G. N. Tret'yakov presented an interesting report on ways of lowering the costs of earth-rock operations. In the report he reminded us that the rock excavation volume for one hydrotechnical construction project in mountainous regions may range between 2-5 million cubic meters and the operation may continue for 2-3 years. The past decade was characterized by the growth of the total volume of rock excavation along with simultaneous cost increases. Moreover, the production-volume growth rates are outstripping the development rate of the machinery needed for rock excavation, especially in mountainous areas. The currently-used drills, loaders, and transporters do not meet the requirements of rock excavation operations in the construction of hydrotechnical structures in mountainous regions.

A number of progressive methods have been introduced into rock excavation operations during recent years. They are intended to lower costs and raise the quality of operations such as preliminary contour blasting, directed blasting, and others.

Cost decreases, labor productivity increases, and shorter rock excavation periods at hydrotechnical projects can be achieved during the Ninth Five-Year Plan by means of the following basic methods: optimization of production-work design and work organization; equipping rock excavation projects with new and modern equipment to accomplish the basic tasks of drilling, loading, and transporting; and applying the construction norms and regulations in conformance with the actual indicators achieved at leading projects.

The implementation of the stated measures concerning preliminary evaluations can lower rock excavation costs 25-30 percent and labor expenditures up to 50 percent.

V. Ya. Shaytanov told of work in the field of optimizing the organization of the preparatory period which occupies up to 30 percent of the total construction period. Methods have recently been formulated concerning the shortening of construction periods and the lowering of the preparatory

operational costs involved in such things as the industrialization of a project's production base and the erection of temporary dwellings. Other methods involve the further development of building industry bases, the improvement of the construction organizations' organizational structure, and an increase in the level of trust specialization.

I. S. Zavalishin showed that the most important way of lowering construction costs, shortening construction periods, and increasing work quality is the further specialization of construction organizations and the constant expansion of the share of work performed by contractors. A new type of contracting organization must be created that will be able to perform all the work in its specialization with its own resources and using its own interrayon bases and field-type maintenance facilities. A gradual changeover to contract methods is becoming completely natural as a result of the considerable progress in construction technology and the real possibility of creating a mobile construction entity and sufficient high-quality housing that can be easily assembled and disassembled. It is necessary to display initiative in developing a system for putting construction on a contract basis. Moreover, the nomenclature of the contracting organizations must be determined along with their structures, scope of operations, interrayon base locations, and the size of the portable operations equipment.

The following scientists from higher educational institutions and scientific-research institutes took part in discussing the reports and made very interesting suggestions: doctors of technical sciences and professors F. F. Gubin, V. S. Eristov, N. N. Maslov, N. P. Rozanov, K. A. Mal'tsov; Gidroproyekt and specialized organization workers P. A. Pshenitsyn, S. N. Popchenko, I. A. Terman, M. A. Bogomol'nyy, O.P. Zhebenev, V. M. Degtyarov, V. M. Kondrat'yev, B. M. Shkundin, A. N. Ter-Oganesyan, D. D. Sapogin, Z. G. Yashchenko, L. G. Zhdanov, V. I. Stankevich, A. N. Mordovina, A. M. Lipkind, I. Ye. Lomov, I. P. Sergeyev, S. V. Tolkachnik, Yu. Ye. Chumichev, N. P. Votyakov, and others.

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ELECTRIC POWER AND RELATED EQUIPMENT

UDC 620.91:621.1:061.6:061.75

CONTRIBUTION OF THE TEPLOELEKTROPROYEKT INSTITUTE OF USSR POWER ENGINEERING

Moscow ELEKTRICHESKIYE STANTSII No 4, 1974 pp 2-8

[Article by I. A. Alekseyev, director of Teploelektroproyekt Institute, and N. L. Oyvin, chief specialist of Teploelektroproyekt Institute]

The development of electric power engineering in the Soviet Union is inseparably linked with V. I. Lenin's name. On his initiative, the first state plan for the electrification of the country -- GOELRO -- was developed in 1920. The GOELRO plan was statewide. It provided not only for construction of electric power plants and networks, but also for the development of the entire national economy of the country on the most perfect technical basis -- electrification. In this connection, V. I. Lenin called the GOELRO plan the second party program.

Under the guidance of the Communist Party of the Soviet Union, the people materialized this plan ahead of schedule by 1931. Much credit in the successful fulfillment of the GOELRO plan belongs to the Soviet designers who prepared the plans for the first projects of the Soviet power engineering: Shatura, Kashira, Nizhniy Novgorod, Shterovka, Ivanovo, Kizel, and other electric power plants.

On 18 April 1924, a subdivision was created within the Main Administration of the Electrotechnical Industry (Glavelektro at VSNKh [All-Russian Council of the National Economy]) for designing thermal electric power plants which grew into the All-Union State Institute for Designing Thermal and Atomic Electric Plants and Electric and Thermal Networks -- the Teploelektroproyekt Institute.

At the present time Teploelektroproyekt has 12 branches: Gor'kiy, Kiev, Leningrad, L'vov, Moscow, Novosibirsk, Riga, Rostov, Central Asiatic, Tomsk, Ural, and Khar'kov.

The Teploelektroproyekt Institute develops problems of long-range development of power engineering in the country and technical specifications for the construction of thermal and atomic electrical power plants, thermal networks, electric power transmission lines, and substations.

Since 1962, the designing of power systems and electric power transmission lines has been done by Energoset'proyekt [All-Union State Planning, Surveying and Scientific Research Institute of Power Systems and Electric Power Networks] which was created on the basis of subdivisions yielded by Teploelektroproyekt and Gidroenergoproyekt [expansion unknown].

Arbitrarily it is possible to outline the following stages in the development of the designing of thermal electric power plants and, consequently, the stages of the development of technical solutions by the Teploelektroproyekt Institute.

The first stage -- the designing of electric power plants which were constructed by GOELRO plans mainly by using imported equipment.

The second stage -- the prewar stage characterized by the use of domestic series equipment, which made it possible to search for original solutions for the first standard designs of electric power plants.

During the war years Teploelektroproyekt performed extensive work connected with the relocation of our power engineering structures to the eastern regions of the country and with the restoration of electric power plants and power transmission lines in liberated regions.

The third stage (after the Great Patriotic War) is characterized by a wide use of repeated designs and a transition to standard designing with the use of cross connections between units for main steam and water pipelines.

The fourth stage is connected with the changeover of TES [thermal electric power plants] to an industrial basis and is characterized by the use of block diagrams for their technological equipment and standardized construction units of precast concrete.

Under the conditions of fuel shortage and devastation, V. I. Lenin gave his particular attention to the necessity of using the low-quality local fuels. This complex problem was successfully solved by the Soviet engineers in spite of the fact that they had no previous experience in this matter. Soviet power engineers developed methods for burning at least 60 varieties of fuel, including shale, brown coal from newly discovered fields, and wastes of coal processing, which was reflected in the designs by TEP [Teploelektroproyekt].

Until 1941, electric power plants were designed chiefly for burning low-grade fuels, including peat, Moscow and Kizel area coals, and anthracite dust.

From the first days of the implementation of the electrification plan, all equipment had to be purchased abroad. Soviet power engineers and, primarily, the designers, made a thorough study of foreign experience and ensured the designing and construction of thermal electric power plants at a high engineering level corresponding to the latest achievements of world science and technology.

In the thirties, a new branch of industry was created in cooperation with machine-builders which became an important step in the development of the technical progress in power engineering. Teploelektroproyekt, by whose engineering assignments the country's machine-builders have been creating power engineering equipment for thermal electric power plants, plays an important role in the solving of this problem.

In 1926, almost all boilers produced steam at a pressure of up to 18 kg-force/cm^2; in 1935, the basic parameters were 30-35 kg-force/cm^2, 400-425 degrees C. After 1945, the boiler-and-turbine industry switched to manufacturing high-pressure equipment for steam parameters in turbines of 90 kg-force/cm^2 and 500 degrees C. The changing to these parameters ensured an economy of 15 percent for the electric power plants. For these steam parameters, which remained as basic in power engineering for 13 years, the institute developed seven standard designs of the main structures of electric power plants in 1952-1954.

As of 1959, new steam parameters were adopted for series equipment of large thermal electric power plants:

130 kg-force/cm^2, 565/565 degrees C (with steam resuperheating) for turbines of 150 and 200 Mw installed in KES [expansion unknown]. Changeover to these steam parameters made it possible to increase economy of TES by 10-12 percent;

130 kg-force/cm^2, 565 decrees C (without resuperheating) for district heating system turbines installed at TETs [heat and electric power plants] of 25 and 50 Mw with steam bleeding and counterpressure, and then 100 and 135 Mw.

In 1956-1958, standard designs were developed for main structures of GRES-1200 [state regional electric power plants-1200] with turbines of 160 and 200 Mw and TETs-350 with turbines of 50 and 100 Mw for the above-mentioned steam parameters.

The standard design of condensation electric power plants envisaged a changeover to a block diagram without steam and feed water cross connection and a transverse arrangement of turbines in the engine room. Concrete was used widely and structural designs were standardized, which made it possible to work out a catalog of reinforced concrete products. Standard designs for main structures of GRES-1200 and TETs-350 have been used at many electric power plants.

In 1958, in accordance with the engineering specifications of Teploelektroproyekt, Soviet plants started manufacturing units of 300 Mw for steam parameters of 240 kg-force/cm^2 and 560/565 degrees C with steam resuperheating). The changeover to these parameters from 130 kg-force/cm^2 and 560/565 degrees C lowered the specific fuel consumption by 4 percent.

For maximum industrialization of the construction of such units by using standardized reinforced concrete components produced by plants, a universal

standard design with several modifications was developed. This made it possible to use it for constructing KES and TETs operating on various types of fuel and the power of turbine units and boilers with parameters of 240 kg-force/cm^2, 560/565 degrees C and 130 kg-force/cm^2, 560/565 degrees C. This universal design was used for constructing 28 main structures of electric power plants.

In 1967-1968, a standard design "67-68" was developed instead of the universal design.

In the standard design "67-68," particular attention was given to improving the operational conditions of units of 200 and 300 Mw working on coal dust and on gas and oil fuels, further industrialization, reducing the amount of labor in construction, as well as improving the technical and economic indexes.

So far, 29 condensation electric power stations and steam electric stations have been built or are under construction by the design "67-68." This modernized design provides for the idea of the organization of rapid construction which was proposed by the USSR Minenergo [Ministry of Power and Electrification].

For example, the first power unit of the Ladyzhin GRES was put into operation in 1970 and the remaining five in 1971. Thus, the construction of the GRES of 1800 Mw was completed in 48 months since the beginning of construction, that is, 16 months sooner than the standard deadline.

Further improvement of the technology of construction units as well as of the technology of construction jobs made it possible to complete the first section of the Zaporozh'ye GRES (4 units of 300 Mw each) in record time -- in 32 months, that is, 15 months sooner than the standard deadline, or 5 months sooner than the 4 units of 300 Mw each at the Ladyzhin GRES.

Units of 300 Mw for supercritical steam parameters have been introduced widely. The first 300 Mw units were put into operation in 1963, and by 1 January 1974 there were 116 such power units in operation.

The economics of thermal electric power plants is determined by the indexes of such units.

The next step in the development of Soviet heat-and-power engineering was the transition to power units of 500 and 800 Mw. The institute developed designs for TES for such units. In 1967, these designs were used for the first power units of 500 Mw at the Nazarovo GRES on brown coals and 800 Mw with a twin-shaft turbine at Slavyanskaya GRES on ASh [anthracite dust], and in 1971, experimental operation was started with a close-coupled power unit of 800 Mw with two boilers and steam parameters of 240 kg-force/cm2, 560/565 degrees C at the same Slavyanskaya GRES. At the Troitskaya GRES, a unit of 500 Mw with a single-hull boiler on Ekibastuz coal was installed.

The institute, in cooperation with the plants, has started work on improving the designs for units of 500 and 800 Mw with close-coupled assemblies, single-hull boilers, large-size auxiliary equipment, and smaller amounts of piping and fittings.

The fundamental improvements of unit plants have two basic solutions: changeover from double blocks to monoblocks and enlargement of the auxiliary equipment of the blocks.

Installation of monoblocks instead of double blocks simplifies their operation, reduces the number of operational and maintenance personnel, and requires considerably less pipeline fittings.

Large auxiliary equipment makes the overall dimensions of the blocks smaller and requires less capital investments as well as reduces the cost of operation.

The technologically advanced solutions include the changeover to gastight designs of boilers with coal dust and gas-oil fuels, and to pressure-charged boilers on gas-oil fuel. The use of pressure charging reduces the expenditure of electric energy on the operation of the boilers by 0.4 percent due to the elimination of exhaust fans, simplifies the operation of the boiler unit, its protection and automation, including fuel control, and simplifies the configuration of gas ducts. Creating dependable pressure-charged boiler units is one of the most important and difficult problems of the boiler-building industry. Its difficulty is the developing of an absolutely gastight combustion chamber and the entire tract of the boiler unit.

Technical specifications of the main and auxiliary equipment for these units were developed by Teploelekrtoproyekt.

In connection with the planned wide introduction of 500 and 800 Mw monoblocks and the changeover of the plants to the manufacturing of larger equipment by the specifications of the institute, it became necessary to develop new designs which would take into consideration the prospects of using the new equipment. In 1968, the institute started developing a technical and economic report on GRES with 500 Mw units operating on Ekibastuz coal which was completed in 1969.

In 1970, a technical and economic report (TER) was published on GRES with 800 Mw units and single-hull boilers operating on gas-oil fuels.

In 1970-1973, on the basis of TER, Teploelektroproyekt developed designs of gas-oil KES with 800 Mw units for the Zaporozh'ye, Uglegorsk, Karmana, and Ryazan' GRES.

At the present time, the plants working on the technical specifications of Teploelectroproyekt are designing a boiler for a 500 Mw unit for the complex of electric power plants working on Ekibastuz coal.

TER shows technical and economic expediency of building a group of four electric power plants on the basis of the Ekibastuz coal field 4,000 Mw each, that is 8 x 500 Mw.

The development of the power industry in Siberia is a particularly large-scale project.

The construction of the Kansko-Achinsk Fuel and Power Base is considered to be of statewide significance. The huge resources of inexpensive Kansko-Achinsk coals make it possible to consider them not only as an economical fuel for satisfying the needs of Siberia, but also as a lower grade coal for the country as a whole. However, Kansko-Achinsk coals are not transportable in their usual form. Their moisture content is 40 percent, and their calorific power is only 3,500 kilocalories/kg.

The expedient scale of the processing of Kansko-Achinsk coals in the near future is evaluated at 50-70 million tons of raw coal per year. The main direction in the utilization of Kansko-Achinsk coals is to produce electric energy at powerful thermal electric power plants built near the fuel source. Their electric energy is intended for the local power system and for transmitting to the European regions of the country through direct current transmission lines of 2,200 kV. In the Siberian OES [Integrated Power System], it is planned to put into operation before 1980 three units of 800 Mw each at the Berezovskaya GRES and to start the construction of three GRES. It is planned to add several more powerful GRES here in a more remote future. At the present time, the institute is developing TER with single-hull gas-tight boilers operating on Kansko-Achinsk coals. On the basis of the technical specifications of the institute and with participation of scientific-research institutes and Teploelektroproyekt, the plant is developing a design of a boiler unit for an 800 Mw block operating on Kansko-Achinsk coals. Considering the large scale of the construction of electric power plants operating on these coals, in the far-reaching plans for 1990, it will be necessary to develop main units of higher capacities after having introduced the 800 Mw units.

The next step in the further increasing of the unit power of the thermal power units is to develop a unit of 1,200 Mw. On the basis of the institute's technical specifications, the plants have developed designs of a close-coupled turbine of 1,200 Mw for a supercritical steam pressure -- the largest turbine in the world -- and a single-hull boiler unit with pressure charging with a capacity of 3,950 tons/hr for operating on gas and fuel oil. According to the institute's project, two of such units will be installed at the Kostroma GRES. It is planned to complete the pilot unit by 1975.

According to the prognoses for the development of the power engineering for 1990, it is planned to introduce the capacities at the electric power plants chiefly by putting into operation large units of supercritical pressures of 500, 800, and 1,200 Mw, which will substantially increase the technical level of the Soviet power industry. According to plan, the capacity of such units will be approximately 80 percent of the GRES capacities for 1990.

The enormous scale of the introduction of large capacity units will make it possible to increase their average capacity from 230 Mw in 1972 to 500-600 Mw in 1990 and to bring this index close to the analogous index in the advanced foreign countries. Under these conditions, the increase in the qualitative characteristics of units of 500, 800, and 1,200 Mw is acquiring an exceptionally important significance. Therefore Teploelektroproyekt has proposed additional technical requirements for industry with respect to increasing the dependability and economy of the operation of these units. These requirements stressed the necessity of a high maneuverability of the 500, 800, and 1,200 Mw units. Along with this, it is necessary to reduce the amount of the auxiliary equipment, to switch to a unifilar system of high-pressure heaters and all pipelines in order to simplify the layout and operation of the equipment, as well as to lower the costs of the pipelines.

The rise in the technical level of thermal electric power plants ensured a decrease in the specific fuel consumption at the electric power plants. For example, in 1965 it was 413, in 1970 -- 366, in 1972 -- 354, in 1973 -- 348, and in 1975 it will be 340 g/(kWh).

A fundamentally new direction in the development of the power industry was the start-up of the world's first atomic electric power plant of 5 Mw in 1954. Its designing was done with active participation of Teploelektroproyekt since 1951.

In the subsequent years of 1956-1964, designs were developed for large experimental industrial AES [atomic electric power plants], including the first units of the Novovoronezhskaya and Beloyarskaya AES with various types of reactors. In 1966, the institute became the chief designer of atomic electric power plants.

During the Eighth Five-Year Plan, on the basis of the institute's designs, the second units of the Novovoronezhskaya AES of 365 Mw and Beloyarskaya AES of 200 Mw were put into operation, and the construction of the third unit of the Beloyarskaya AES with a fast neutron reactor of 600 Mw was started. On the basis of the design of a standardized 400 Mw unit developed by the institute, the construction of the Novovoronezhskaya, Kol'skaya, Armenian AES, as well as the AES in the GDR and NRB [People's Republic of Bulgaria], is progressing. During the period of this five-year plan, AES with various types of reactors of 50, 100, 200, and 365 Mw were being made operational, and designs of AES with 440 and 1,000 Mw reactors were developed. It was proved in practice that atomic electric power plants can, under certain conditions, compete with thermal electric power plants with respect to their effectiveness.

The obtained results made it possible for the institute to work out technical and economic principles for the development of atomic power engineering in the future and to substantiate the scale of AES development to 1990, and to select the points and sites for the construction of AES of from 2 to 6 x 1,000 Mw, which will be introduced before 1990, as well as to set up technical assignments for industry for the main and auxiliary equipment of AES (reactors of 500, 1,000, 1,500 Mw; turbines of 1,500 rpm with capacities of 500 and 1,000 Mw operating on saturated and superheated steam, main circulation pumps, steam generators, special cables, and others).

The creation of semipeak-hour thermal electric power plants equipped with highly maneuverable steam turbine units which can be stopped daily during the night is an important problem. These plants will produce a noticeable saving of fuel.

On the basis of the technical specifications of Teploelektroproyekt, plants must develop the designs and produce units of 500 Mw for subcritical pressures in turbines of 130 kg-force/cm2 and a temperature of 510/510 degrees C. These parameters were adopted to ensure a low cost of the established 1 kw. The long-term plan for 1990 envisages the installation of semipeak-hour generating capacities. For the same purpose, it is planned to introduce peak-hour gas turbine electric power plants. In the future it will be necessary to raise the capacities of the gas turbine electric power plants with 100 Mw units and to develop designs for electric power plants with gas turbine units of 200 Mw and higher.

At the present time, gas turbine units GT-25-750 are operating at the Kiev TETs and GT-100-2 at the Krasnodar TETs. They were assembled according to the designs of the Kiev and Rostov branches of the institute.

Installation of district heating systems on the basis of combined production of thermal and electric energy is one of the important directions in the development of the USSR power industry. It ensures a higher fuel utilization factor in the power industry and rationalization of the structure of the country's fuel-energy balance.

Teploelektroproyekt substantiated the technical expediency and economic effectiveness of concentrating TETs capacities, increasing the unit capacities of the main and auxiliary equipment, and raising the initial steam parameters. Since the first steps in the development of district heating, the institute has been working on schemes of heat supply to cities and industrial centers. In the last 10 years alone, the institute developed about 200 schemes of heat supply. In the last few years, the institute has been designing powerful TETs from 500 to 1,500 Mw. It prepared a TER on the development of heat supply in the USSR for 1970 which confirmed the technical directions in the part of the economic effectiveness of concentrating TETs capacities. The institute's TER "On the Development of Heat Supply with the Use of Nuclear Fuel" should be specially mentioned. The conclusions and recommendations of this report are used in preparing assignments to industry for the main equipment and in designs done by the institute for a number of large atomic TETs. The institute has done a large volume of work in connection with the designing of heat networks.

Important shifts must take place in ensuring thermal energy for the national economy through large-scale construction of heat and electric power plants on the basis of high-power units and the construction of a series of TETs according to a single unified design. The goal is to use the experience in the construction and operation of the experimental industrial Rostov TETs-2 and to speed up the development of such a design with consideration for the possibility of installing 80, 110, and 135 Mw turbines at the series TETs.

The next task is to develop a design for the series TETs with units of up to 250 Mw for supercritical pressures and with pressure-charged single-hull boiler units.

The development of the electrotechnical part of the designs of thermal electric power plants depends on the development of power systems and the electro' :chnical industry. The close ties with scientific-research organizations and plants ensured progress in this part of the designing. By the end of 1965, the Unified Power System of the European Part of the USSR was formed.

In the eastern regions of the country, the formation of the unified power systems of Cent.al Siberia, Northern Kazakhstan, Central Asia, Transbaikal, and the Far East is in progress. The development of power systems and their unification will make it possible to create the Unified Power System of the Soviet Union later.

Teploelectroproyekt created and was constantly improving the designs of high-voltage distribution systems (from 6-10 to 750 kv). The designed ORU [outdoor distribution systems] of 500 kw which have been introduced at a number of power plants have positiv. operational characteristics. The institute initiated the use of autotransformers in the power industry. They are widely used at electric power plants and substations. The same can be said about two-winding and three-winding transformers for KES and TETs which have a regulator of voltage under a loa.. Main electrical wiring diagrams of high dependability were created for 500, 800, and 1,200 Mw units.

The forthcoming new stage in the development of the power industry connected with the changeover to 500, 800, and 1,200 Mw units, in the part of the control systems, will be characterized by solving the complex problems of automating thermal processes of electric power plants and the entire power industry as a whole.

The 24th CPSU Congress set up a task for the USSR industry to create during the Ninth Five-Year Plan a basis for an automated control system (ASU) for the national economy. For the solving of this problem, the USSR Minnenergo [Ministry of Power and Electrification] is creating an automated control system for the power industry of the country (OASU "Energy"). The lower step of this system is ASU TES which is being designed by the Teploelektroproyekt Institute.

The ASU TES (ASUP) will be solving such problems as the economic distribution of loads among the units; regulation of capacities on a large scale, processing and exchange of information with power systems not only regarding the technological and technical parts of TES, but also regarding their economic and management activities. It is natural that computing technology must be used widely for this purpose.

With the development of heat-and-power engineering, it was important to solve problems of technological w ter supply and hydraulic removal of ashes and

slags. The systems and schemes of technological water supply were improved during the last period when the capacities of power units and electric power plants increased sharply and the requirements for the purity of the environment rose. The following technological solutions have been developed and are being introduced.

Cooling water reservoirs are being designed on the basis of hydrothermal modeling with the use of a new type of water intake. Closed reinforced concrete channels are replaced with open ones. Unit stations are used instead of central pumping stations. Large cooling towers with the sprinkling area of 6,400 m^2 are being installed and cooling towers with the sprinkling area of 10,000 m^2 are being designed. In cooperation with the Hungarian Institute of Power Engineering, Teploelektroproyekt has developed coolers of a fundamentally new type which combine the advantages of the "dry" and evaporation cooling towers, the so-called combination units, for which the institutes have obtained patents.

Designs are being prepared for high-capacity ash dumps with a small height of earth dams and with aggradation of ashes and slags on a drained base.

In order to eliminate the harmful effect of the cooling and hydraulic ash removal systems on the environment, the designs provide for the cooling of the circulating water before dumping it into water reservoirs, circulating systems of hydraulic ash removal, special complexes of purification devices, and elimination of the dumping of polluted waste waters into water reservoirs. Systems are designed for supplying ashes and slags from TETs to consumers if they are available.

Large-scale work is in progress on the introduction of steam and gas plants (PGU).

The first large steam and gas plant of 200 Mw designed by TsKTI [Central Scientific Research, Planning and Design Boiler and Turbine Institute] imeni I. I. Polzunov consisting of a gas turbine GT-35/44-770 and a steam turbine K-160-130 was put into operation at the Nevinnomyssk GRES according to the design of Teploelektroproyekt. After generalizing the experience of its operation and solving the technical problems of the operation of PGU on heavy types of fuel, a wider introduction of PGU will be possible. It is necessary to speed up the entire complex of scientific research, designing, refining and adjusting jobs on the pilot equipment.

Steam and gas plants may be one of the possible means of increasing the effectiveness of the operating and newly constructed GRES, because the efficiency (net) of PGU may exceed 40 percent.

The construction of thermal electric power plants of high capacities must be solved in such a way as to ensure complete observance of the requirements for the protection of the environment against pollution. In order to protect the atmosphere from pollution by wastes, it is necessary to continue

work on increasing the effectiveness of electric filters and other types of ash catchers, to activate the work on the creation of economically acceptable industrial methods of purifying flue gases or the initial fuel (of highly sulfurous fuel oil) from sulfur oxide and sulfur content, and to develop such burning devices, their layout in the boiler units, and the operating conditions of boilers which would prevent the dumping of nitric oxide into the atmosphere.

It is necessary to work out designs of chimney stacks 400 m high with a dependable anticorrosive insulation and to develop industrial methods of erecting them in short periods of time. Utilization of ash and slag residues of hard fuels for construction purposes, particularly for erecting protective dams of ash dumps, is an important problem. The institute is actively engaged in this problem.

The designers and researchers of the Teploelektroproyekt Institute still have to do a lot for lowering the pollution of the atmosphere, water basins, and soil by the wastes of thermal electric power plants; greater care should be taken with respect to the land, forests, and other natural resources of our country.

Projects on technological reprocessing of highly sulfurous fuel oil by the IVTAN [expansion unknown] and ENIN [Power Engineering Institute imeni G. M. Krzhizhanovsky] methods for increasing the fectiveness of their use in the power industry and preventing the pollution of the atmosphere and corrosion of the equipment by removing sulfur and other valuable components are of special interest. These methods will be tested at two TETs on the basis of Teploelektroproyekt's designs.

The problems of generating electric energy by direct transformation, particularly MGD [magnetohydrodynamic]-generators, are also of great interest. These projects should be developed so as to obtain dependable industrial units no later than 1980-1985.

On 18 April 1974, it will be the 50th anniversary of the foundation of the All-Union Order of Lenin State Design Institute Teploelektroproyekt.

Fulfilling the great Lenin plan of overall electrification of our country, the institute, as the largest design organization in the country, in a half a century beginning with the GOELRO plan, has developed designs for over 400 electric power plants.

Between 1960 and 1973 alone, 96,500 Mw turbine capacities were put into operation on the basis of the design specifications of the institute. This represents 80 percent of the capacities introduced at all electric power plants of the Soviet Union.

Moreover, 85 electric power plants with a total capacity of over 20,000 Mw were built abroad according to the institute's designs.

Carrying out the resolutions of the 24th CPSU Congress, Teploelektroproyekt is doing all the work on the development of the country's heat-and-power engineering in cooperation with other power engineering and machine-building design and research institutes, operational and construction organizations, and power machine-building plants.

The Party and the government gave high recognition to the work of the institute: for its achievements in designing thermal and atomic electric power plants, as well as for other projects in the field of power engineering, the institute was awarded the Order of Lenin in 1962. In 1970, in commemoration of Vladimir Il'ich Lenin's 100th birthday, the members of the institute were awarded the Lenin's Diploma of the CPSU Central Committee, Presidium of the USSR Supreme Soviet, USSR Council of Ministers, and VTsSPS [All-Union Central Trade Union Council]. In 1972, on the 50th anniversary of the USSR, the members of the institute were awarded the Anniversary Medal of the CPSU Central Committee, Presidium of the USSR Supreme Soviet, USSR Council of Ministers, and the VTsSPS.

It can be said with confidence that the many thousand members of the Order of Lenin Institute Teploelektroproyekt, who are celebrating their 50th anniversary, will successfully cope with the tremendous tasks of further development of the Soviet power engineering in the direction of progress conformable to the scientific and technical revolution.

STAT [redacted]

APPENDIX 5a

b. UHV Transmission Technology and HVDC Transmission System Experience and Design

ELECTRIC POWER AND RELATED EQUIPMENT

UDC 621.314.222.6.001.1

MORE POWERFUL HIGH VOLTAGE TRANSFORMERS INTRODUCED

/Article by A. I. Mayorets, deputy minister of the USSR Electrical Engineering Industry; Moscow, Elektrotekhnika, Russian, No 3, March 1973, pp 1-6/

The primary tasks in the improvement of already developed transformers and in the development of new more powerful high voltage transformers have been accomplished.

The continuous growth of the capacities of electric power stations and of the need for electric power in our country, which will continue with great intensity in the future, raises the problem of manufacturing high-power transformers. By means of increasing the individual capacity of transformers and by increasing the voltage of electric power transmission it is possible to improve the economic and engineering indexes, reduce the cost, and raise the efficiency of electric power transmissions.

The progress in the area of transformer building is based on improved designs, on the one hand, and on an essential improvement of the properties applied in magnetic and insulation materials, which make it possible to increase the intensity in them, on the other hand. As a result this leads to a reduction in weight, dimensions, and waste per unit of power. Only on this basis is it possible to further increase the individual capacity of large transformers, since their weight and dimensions are limited by the conditions of transport by rail.

The growth of the capacity of the three-phase transformers and of a group consisting of single phase units during the last 20 years and the expected growth in the comparable period of time are shown in figure 1.

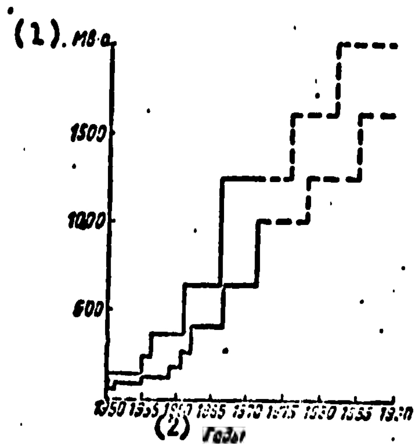

Figure 1. Growth of Raised Capacity of Power Transformers

--- three-phase transformers — - group of single phase transformers

Key:

1. millivolt amperes
2. years

The three-phase transformerswith a capacity of 1000 millivolt amperes on a voltage of 330 kilovolts (Figures 2, 3) /Photos not reproduced/ was manufactured and put into operation in the Soviet Union in 1971, and in 1972 a three-phase transformer with a capacity of 630 millivolt amperes on 500 kilovolts was put into operation.

At the present time in the Soviet Union transformers with a higher voltage up to 380 kilovolts inclusive are manufactured only in the three-phase form, with a voltage of 500 kilovolts in the three-phase and single phase form depending on the capacity, and with a voltage of 750 kilovolts only in the single phase form. The grid capacity of 1150/500 kilovolt automatic transformers intended for production in the current decade will amount to 1600 millivolt amperes, and in the future it should be increased to 2500-3000 millivolt amperes. The reduction of ratios and losses with the increase of individual capacities of transformers can be seen from the table based on examples of 220 and 330 kilovolt class three-phase transformers.

1 Тип трансформатора	2 Год изготовления	3 Потери х.х., вт/ква	4 Потери к.з., вт/ква	5 Вес стали, кг/ква	6 Вес меди, кг/ква	7 Полный вес, кг/ква
8 ТДЦГ-40000/220	1954	2,63	5,05	0,77	0,256	2,85
9 ТДЦ-125000/220	1963	1,41	4,96	0,43	0,183	1,41
9 ТДЦ-360000/220	1961	0,97	4,03	0,317	0,121	0,923
9 ТДЦ-630000/220	1967	0,476	3,01	0,254	0,107	0,6
10 ТЦ-1000000/330	1971	0,453	2,1	0,23	0,089	0,515

Key:

1. Type of transformer
2. Year of manufacture
3. Losses x.x., watt/kilovolt-ampere
4. Losses, k.z. /short circuit/, watt/kilovolt-ampere
5. Weight of steel, kilogram/kilovolt-ampere
6. Weight of copper, kilogram/kilovolt-ampere
7. Full weight, kilogram/kilovolt-ampere
8. TDTsG
9. TDTs
10. TTs

The development of transformers with greater capacities was connected with the growth of the capacity of generators, since the most economic solution for electric power stations is the development of generator-transformer units. But as long as it is necessary to transform the power processed by electric power stations into various voltages, the volume of work on transformers will increase radically. For example, three-phase step-up 400 millivolt-ampere transformers with higher voltages of 110, 150, 220, 330, and 500 kilovolts were developed for a 300 megawatt unit. Accordingly, it becomes necessary to develop a gamut of automatic transformers of various capacities with various combinations of voltages for the provision of power linkages and alternating currents between networks with various voltages.

The growth of rated voltage in power transformers in the postwar period, and the expected growth in the near future are shown in figure 4. The 1960's represented a period of intensive development in 330 and 500 kilovolt networks, while in the current five-year plan 750 kilovolt networks are already under construction, and after them there will appear 1150 kilovolt networks with alternating current and 1500 networks with direct current.

In 1972 a group of 750/330 kilovolt automatic transformers with a capacity of 1000 millivolt-amperes was manufactured for the first 750 kilovolt industrial line in the USSR and in Europe, which is under construction in the Ukraine (figure 5) /Photo not reproduced/. At the present

time there is in operation a group of 750/500 kilovolt automatic transformers with a capacity of 1250 millivolt-amperes*, which is intended for the connection of 330 kilovolt networks in the Ukrainian SSR with 500 kilovolt networks in the RSFSR through the 750 kilovolt lines under construction.

In 1970-1972 experimental single phase $\frac{1150}{\sqrt{3}} / \frac{500}{\sqrt{3}}$ kilovolt automatic transformers with a capacity of 210 millivolt-amperes each were manufactured for the purpose of conducting research on an experimental section of a 1150 kilovolt line (Figure 6) /Photo not reproduced/

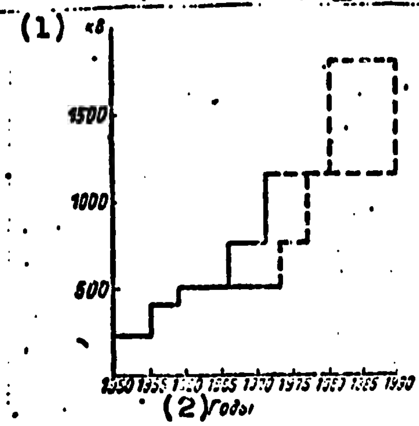

Рис. 4. Рост номинального напряжения силовых трансформаторов.
——— промышленных; - - - - опытных.

Figure 4. Growth of Rated Voltage of Power Transformers

Key:
1. Kilovolts — Heavier line signifies industrial.
2. Years — Lighter line signifies experimental.

Only a few years ago it was assumed that the highest rated voltage of alternating current networks in the future will not exceed 1000-1300 kilovolts, however, now many specialists in the USSR and abroad consider that the next step with regard to voltage after 1100-1200 kilovolts (1150 kilovolts has been adopted in the USSR) will be voltages on the order of 1800 kilovolts, the mastering of which it is assumed will take place after 1990.

However, the development of such transformers presents special difficulties, because of transport limitations (both with regard to weight and maximum dimensions) and because of

* The first group of analagous automatic transformers for the Konakovo-Moskva experimental electric transmission line was manufactured in 1967.

the necessity to increase the capacity within a unit in comparison to 500-750 kilovolt transformers. Already the transport weight of high-power transformers, transported without oil, is 400 tons and the suspension type transporters used for transporting them have 32 pairs of wheels (figure 7) /Photo not reproduced/, and the overall length of such a hook-up exceeds 50 meters. It is not exceptional that in order to increase the individual capacity of transformers it becomes necessary to resort to transporting them to the point of installation in sections. The intermediary phase of such designs will be units transportable in transport containers.

A very tempting solution to the problem is water transport, but, unfortunately, it can only be used in individual cases. Moreover, it would be desirable that the design of the transformers and the methods of their transport and assembling, while being put into operation, would exclude the moistening of insulation, thus guaranteeing the maintenance of the high insulation characteristics of the transformers obtained as a result of careful thermal vacuum processing of the insulation at the plant.

In order to develop transformers for future voltage requirements a large volume of special research and development is needed. The basic points are as follows:

the development of a group of measures which will provide for the thorough limitation of switching and lightning surges (including the development of new excess voltage suppressors);

research on allowable voltages in the internal insulation of transformers under the prolonged influence of running voltage (in addition to research on prototypes and models for accumulating operational experience experimental industrial operation is also necessary in certain transformers of the 220-500 kilovolt class with incraased voltages in the insulation);

research on new designs and circuits for the connection of windings;

the procurement of new magnetic and insulation materials, which will provide for the maximum capacity of transformers and better engineering and economic indexes with the assigned means of transport.

Parallel with the development of 1150 kilovolt alternating current electrical equipment scientific research and experimental design work is also being conducted on the

development of equipment for 1500 kilovolt voltage direct current electric transmission lines in accordance with the directives of the 24th Congress of the CPSU. The application of both types of voltage are planned in the prospective drafts of our development in the USSR.

The development of transformer equpment for direct current electric transmission lines presents special difficulties, since in working on installations with high voltage rectifier and inverter units, it undergoes a specific influence which has not yet been sufficiently studied. For example, the regularities involved in the installation of high-voltage installations under the influence of direct current greatly differ from such regularities under the influence of alternating current. Therefore, enforced research and development of electrical equipment for 1500 kilovolt electric transmission lines, and also the developments of laboratory installations and stands necessary for this should be considered as urgent tasks. The operational experience gained during the work on 750 kilovolt alternating current electrical equipment used in the Konakovo-Moscow experimental industrial LEP /Electric Power Transmission Line/ and on 800 kilovolt alternating current equipment in the Volgograd-Donbass line, confirms the necessity and expediency of constructing such installations.

The tasks facing the transformer builders in order to guarantee the necessary growth of the volume of output and technical progress are difficult and varied. Along with the work on the improvement of designs for increasing the reliability and the service life of transformers, there is much to be accomplished in the improvement of the methods and quality of the manufacturing process and also of control methods. In conjunction with the power engineers it is necessary to carry out systematic work on improving preventive and control methods for maintenance of transformers during operation. It is necessary to develop research and production bases.

<u>Tasks in the Area of Design Improvement</u>

At the present time magnetic circuits in high-power transformers are manufactured only from 0.35 millimeter thick cold-rolled steel with specific losses of R_{15} not exceeding more than 1.0-1.1 watt/kilograms. Thanks to the elimination of holes in operating steel, additional losses in it have been excluded because of the curves in the course of the magnetic flow which made it possible to bring losses under open-circuit conditions in high-power domestic transformers to the level of the best transformers made abroad.

Further improvement in the designs of magnetic circuits and reduction of additional losses in them will be achieved by the extensive application of sloping joints and new arrangements in the preparation of laminated sheets, by increasing the space factor in the cross-section of the steel, and also by reducing noise and vibrations. At the present time corresponding research is being carried out.

Windings. At the present time in high-power transformers windings with voltages up to 35 kilovolts are executed by screwing together with a large number of parallel wires continuous coils for voltages within the 110-330 kilovolt range and multiple circuit windings for voltages of 500 kilovolts and higher. Special measues for reducing intercoil gradients during pulse reactions in continuous windings have made it possible to eliminate the installation of capacitive screens and additional insulation of individual coils. In the multiple circuit windings as a result of thorough research circuits have been worked out, which provide for the good distribution of excess voltage between the individual sections of the windings, thanks to which we were able to succeed in providing a high pulse strength throughout the whole insulation structure. Complex wires from several or a large number of transposed conductors are used, which greatly simplifies and accelerates the winding of the windings, while simultaneously reducing additional losses in them. In high voltage windings wires with increased insulation made of compressed cable paper 0.8 millimeters in thickness instead of the usual cable paper 0.12 millimeters in thickness is used, which increased the electric strength of wire insulations by 30-35 percent.

Further improvement in the designs of windings should include research concerning the expediency of introducing and using layered windings, the development and specification of methods for calculating excess voltages in windings with the extensive utilization of ETsVM /Electronic Digital Computer/, the application of copper alloys instead of copper which possess greater mechanical characteristics, research on superconductive materials for use in future cryogenic transformers, and so on.

Insulation. The improvement of insulation in high voltage transformers is connected with further research on oil-barrier designs, the application of rigid form insulation parts for sections of a heterogerous field (edges of the windings, branches at the ends, and so on). The improvement of insulation should be accompanied by an improvement in the quality of oil and its stability.

A considerable reduction of the main insulation intervals between windings can be achieved by means of using hard oiled paper insulation, which fills up the whole interval between them. A design with such insulation allows higher electrical gradients, however, its use is connected with a thorough examination of the structure of the windings in the transformer and with a significant complication of the production method and a rise in manufacturing costs. The question concerning the expediency of introducing a similar design for windings can be resolved only on the basis of a detailed study and development of both the design and the manufacturing method, and also a thorough engineering and economic analysis. Such a solution to the question of insulation can become one of the ways of increasing the individual capacity of transformers.

The insulation of windings from the container and between the adjacent faces, for example, by means of using oil-barrier designs analagous to the insulation between windings should also be improved.

Cooling

Recently much work has been done on improving and increasing the reliability of cooling devices with forced oil circulation. The DTs /expansion unknown/ type cooling devices (forced oil movement through the cooler blown by a flow of air) underwent considerable redesigning. In 1971 at the Zaporozh'ye Transformer Plant new DTs cooler systems were introduced on the basis of the application of slowly revolving ventilators, new electric pumps with a shielded stator and a new design for the bimetallic coolers. In the newly designed transformers the location of the coolers is provided for in the container. In instances, when such a disposition is difficult, a group cooling installation (GOU) consisting of several coolers distributed throughout the frame along with an automatic control panel has been worked out. The possibility of relocating the GOU by rail has been provided for in the plans. A great amount of research has been done on heat emission of the windings in the event of forced oil circulation in them. This extremely effective system of cooling was applied in transformers with a capacity of 630 and 1000 millivolt-amperes. This key work will be continued and as a result should lead to the development of a gamut of standardized highly effective coolers that are reliable in operation. The coolers will be equipped with a complete set of control and measuring instruments for automatic operation.

It is not exceptional that in order to increase the dynamic stability of windings in high-powered transformers it becomes necessary to resort to increasing their short-circuit voltages.

The elimination of local excessive overheating, which leads to premature aging of the insulation, is an extremely important question for providing continuous reliable operation of high-power transformers. The resolution of this problem is connected with a thorough study of magnetic fields in the transformer and of ways to disseminate heat, which has accumulated in its windings and structural parts.

Essential factors determining the operational reliability of insulation in high voltage transformers are the volume and methods of testing of insulation at the manufacturing plant, and control over its condition during operation. In addition to the single minute testings of the voltage of industrial frequency, as provided for in GOST /All-Union State Standards/ 1516-68, ionization tests with measurements of the level of partial discharges have been included in the volume of control testings on all high-power tranformmers with superhigh voltages. Along with these tests two types of tests are being introduced and approximate operational reactions: ionization testing during prolonged (about 1 hour) applications of alternating voltage equal to 1.3-1.5 working voltage and the testing of switching impulses. It is assumed that in time after an accumulation of a definite amount of experience and after methods have been worked out, these tests can be standardized and introduced in place of the traditional testing by a single minute voltage of industrial frequency and of routine testing by lightning pulses.

A number of scientific organizations are already conducting research on the electric strength of the internal insulation of transformers under experimental influences reproducing operational conditions as much as possible. Besides this it is necessary to conduct more extensive research on the aging of insulation in operation for working out characteristic norms allowable for insulation during operation. Such research should be conducted together with enterprises of the USSR Ministry of the Electrical Engineering Industry and the USSR Ministry of Power and Electrification.

Improvement of Production Process of High-Power Transformers

With the transfer from sheet steel to rolled steel and with the elimination of holes in it the manufacturing process of magnetic conductors for high-power transformers has been considerably simplified. The manufacturing productivity of

Research and experimental work should also be conducted on new methods of cooling (evaporation cooling with the use of lightly boiling liquids, the application of windings made of pure aluminum under very low temperature conditions, and so on).

Increasing Reliability and Service Life

With the development of power systems and the growth of individual capacities the problem of providing dynamic stability of the windings during short-circuiting came to the forefront, and special attention should be given to it. As a result of research accomplished in the USSR, United States, Japan, and in other countries it turned out that in addition to the stretching of usual stresses in the external windings and to compression in the internal windings of core-type transformers during short-circuiting there is observed a manifestation of a loss of stability leading to a deformation of the internal windings. This manifestation has still not been subjected to sufficient study and for the time being no cardinal measures have been worked out for its prevention. The testing of prototypes of windings being conducted at the present time in special installations, which reproduce reactions to which windings are subjected during short-circuiting, should be considered as a temporary measure until there has been a clarification of all the factors which cause this manifestation and until measures have been worked out to prevent it.

In order to increase the dynamic stability of the windings it is very important to improve the method by which they are dried, thus practically excluding or bringing to a minimum any further shrinkage after being put into operation. Along with this it is necessary to work and introduce new designs for molded windings in high-power transformers, which would guarantee definite stresses of their compression even with a certain shrinkage. The application of hydraulic lifting jacks, which in operation would make it possible to carry out the molding of windings without lifting the working part out of the container, has very good prospects. The application of specially processed hard cardboard, which has a low-shrinkage factor, or other materials such as plastic, for example, which is not subject to shrinkage for bracket insulation and intersectional packing of the windings is of essential significance for the successful struggle with shrinkage of windings.

It is necessary to accelerate the work on the development and application of copper alloys for winding conductors with increased mechanical durability.

plates on automated lines, designed in the All-Union Institute of Transformer Building, increased considerably in comparison with the old method of production. After accomplishing linear and lateral layouts on the automated lines the plates are subjected to reduction annealing with automatic regulation of the production routine.

The assembly of the magnetic conductors is accomplished on special assembly tilter-stands equipped with hydrobeams, which provide for an even controlled stress in the pressing of steel. The coupling of the rods is accomplished by bands of glass strips superimposed by a mechanized method. Along with improving quality these mechanisms have led to a radical reduction of labor consumption in the manufacture of magnetic conductors.

In the manufacture of large windings vertical coil-winding machine tools, which assure a denser winding than with the horizontal machine tools, are being used extensively; axial pressing of the coils in the winding process is being introduced. The process of drying the windings is accomplished in vacuum ovens under constant pressure, and in individual cases with cyclic pressure in a hydropress. Work is being done on the mechanization of the coiling of extensively used continuous windings. Experiments are being conducted on the manufacturing method of insulation parts of complex configuration by means of a casting method from paper mass and a formation method from electrocardboard.

The sectional method of assembly is used in the manufacture of containers by which a complex design is made up of relatively simple parts. It is possible to use mechanized methods of welding in these parts. Automatic and semiautomatic welding in a medium of carbon dioxide under a layer of a fusing agent are used in the manufacture of welded structures for high-power transformers. In the years 1973-1975 there are plans to develop mechanized production lines for the manufacture of angle brackets, radiators, and conservers.

Of the production processes involved in high-power transformers the drying of working parts is worthy of special attention. Drying in vacuum ovens with steam heat under a residual pressure of 0.5-5 millimeters rt. st. /mercury column/ and at a temperature of 105-115°C is the method applied in plants in the Soviet Union. Abroad two methods are recognized as more effective.

1. Heating of the working parts of a transformer by means of blowing air heated to 105-115°C with a subsequent vacuum drying under a residual pressure of 0.1-0.01 millimeters rt. st.

2. Heating of the working parts of a transformer by saturated steam or slightly supersaturated steam of an organic liquid, similar to kerosene and having a temperature of 125-140°C, with a subsequent vacuum drying under a residual pressure of 0.1-0.01 millimeters rt. st.

The first method is being applied extensively in Europe and the second method is being used successfully in the United States and Canada. The drying time of transformers with the utilization of petroleum products is approximately half of the time needed, when drying with hot air, and is 2-3 times faster than the drying process in domestic plants.

At the present time research is being done and drafts have been drawn up for vacuum drying installations with the use of hot air.

Parallel with the participation of other ministries research is being carried out on industrial installations for drying transformers with the use of steam from petroleum products. This work should be accelerated.

Transformer Protection, Control and Signaling Apparatus

Modern development in transformer building is raising the requirements with respect to the improvement of existing safeguards and control and signaling instruments to a new level. Dischargers are a basic protective device of the insulation in high voltage transformers. Their protective characteristics on the whole determine and limit the electrical reactions, to which insulation in transformers is subjected. Therefore, improving the dischargers is one of the decisive factors in the question of raising the technical level of transformers being protected by them. A gas relay, which has been successfully used for more than 50 years, numbers among the basic safeguards in transformers.

The gas relay, mass produced in the GDR for all CEMA countries, completely satisfies its own purpose. At the present time work is being done on equipping it with an additional pipe, which will make it possible to extract gas samples, while it is operating without having to remove it from the container. Such an addition would greatly simplify and make servicing of the relay safer.

Recently a branch standard was given to an indicating device for determining the level of oil in the conserver, which will make it possible to give up the application of gas tubes in the conservers and the minimum oil level relays, since this function will be taken over by the magnetically controlled contact indicator.

In order to control the temperature of the upper layers of oil in the transformers TSM /Copper Resistance Thermometer/-100 type thermometric signaling devices supplied by enterprises of the Ministry of Instrument Building, Automation, and Control Systems, are being used. This thermal signaling device has many defects and is in need of being replaced by a new improved instrument. Unfortunately, the Ministry of Instrument Building, Automation, and Control Systems is exhibiting inadmissible slowness in mastering these new thermal signaling devices for the transformer building industry.

The protection of oil found in the transformer is an imperative necessity, since humidification and oxidation of the oil require that it be replaced in order to undergo regeneration. Because of such a great number of transformers in operation this would entail a large amount of unproductive expenditures.

The safeguarding of oil in high-power transformers by means of an elastic film located in the conserver has recently been worked out and put into practice in the USSR. However the massive introduction of this safeguard is being held up by a lack of industrial production of elastic film. The experience gained at the Moscow Electric Plant imeni V. V. Kuybyshev on the utilization of thermoelectric modules to protect the transformer oil from humidification during operation is worthy of much attention.

An analysis of dissolved gases in the oil, according to the composition and quantity of which it is possible to determine the damage caused to insulation already in its initial stage, has been extensively applied abroad in the last decade. In the USSR this method of insulation control has not yet gone beyond the research stage, however, all measures should be taken to speed up this work. A periodic analysis of the gases dissolved in the oil, as foreign experience has shown, makes it possible to prevent accidents as a result of accumulative damage.

So far there is yet to be developed a unit which would protect the container of the transformer from deformation during the development of high-powered discharges in it. As

a consequence of this and as a result of damage to the windings in high-power transformers and subsequent short-circuiting the container is subject to deformation and even its destruction. In connection with the increase of capacities in the power system the need for protective devices, which would limit the amount of pressure inside the container of the transformer, is very great, and, therefore, it is necessary to speed up work on its development.

The tasks which are to be resolved by the transformer builders are varied and complex, but the vast accumulation of experience and the capability of specialists educated in this branch of industry instill a confidence that the tasks facing this branch will be resolved on time.

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

ELECTRIC POWER AND RELATED EQUIPMENT

EQUIPMENT FOR HIGH-VOLTAGE POWER LINES

[Article by Pravda correspondent V. Danilov: "Tamers of Lightning"; Moscow, Pravda, Russian, 16 April 1971, p 3]

It was reported from the rostrum of the 24th Party Congress that high-voltage equipment which will control power transmission lines with a voltage of one million volts and more is being created at the Uralelektrotyazhmash [Ural Electrical Heavy Machinery] Plant. Pravda correspondent visited the plant. We are publishing his report.

High-voltage power transmission lines from Volga and Siberian GES [hydroelectric power stations] extend over thousands of kilometers. High-power switches are located on the routes. They themselves will prevent a catastrophe if a line becomes closed, if lightning strikes it or if a tree falls on the wires. Quite a few things may happen on the enormous route in tayga and in mountains, in the middle of steppes and deserts.

Switches are necessary not only for preventing a breakdown. The country is vast: it is day at one end and night at the other. Here the work shifts are in full swing, and there -- a lull. High-voltage power transmission lines have to be controlled. Equipment turned out by the Uralelektrotyazhmash Plant serves this purpose. For the time being it is designed for voltages of up to 500,000 volts. Power of as yet unprecedented voltages -- a million and more volts -- will flow over the wires in the period of the ninth Five-Year Plan. Control equipment must be ready for its transmission.

The name of the equipment is prosaic -- air switch. But actually this is a unit impressive in appearance and complex in its arrangement. Let us imagine towers with a height of up to 14 meters, placed parallel to each other in three rows. A row is one pole or, as it is called, a phase. Each phase consists of five towers -- porcelain columns reinforced with tension members also made of porcelain. A tank with compressed air is at the base of the column. Toothed contacts through which the current flows are on top.

A line has to be cut off. The operator presses a pushbutton and contacts are disconnected. Is this all? No. Contacts are disconnected, an electric arc forms between them -- as if a blinding lightning flashes. It has to be quenched. Compressed air is fed from the tank for this purpose. It "envelops" the tubular contacts. Now the line is disconnected. And this is done in the course of four hundredths of a second. As they say, in less time than it takes to wink an eye. The same takes place in the case of "unplanned" cutoffs when faults have occurred on a line. In this case the mechanisms are set into operation not by the operator but by a special relay: contacts are disconnected, compressed air rushes upward, and a breakdown is prevented.

The design of equipment for controlling power transmission lines with a voltage of one million volts was created by the collectives of workers of All-Union Electrotechnical Institute imeni V.I. Lenin, Scientific-Research Institute of Uralelektrotyazhmash Plant and by the designers of the enterprises.

Working drawings of the equipment have been received in the air-switches department. Fabrication of components and subassemblies has started. One phase is to be ready in the third quarter.

The first will be followed by the second, third, tenth... They will rise as a reliable guard at the electric-power routes to control the mighty energy.

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UDC 621.3.051:621.3.016.35

SAFETY EQUIPMENT FOR SOUTHERN 750-KV POWER LINE

[Article by E. G. Berlyand, M. I. Gurariy, V. V. Yershevich, Yu. S. Lapitskiy, A. A. Okin, M. G. Portnoy and A. A. Khachaturov: "The Operating System, Stability and Automation of 750-kv Power Transmission Between the Donets Basin, Dnepr, Vinnitsa and L'vov"; Moscow, Elektrichestvo, Russian, No 6, 1970, pp 7-12]

The power transmission line examined in the article is a powerful intersystem hookup being constructed in the Unified Power System [OES] of the South. In designing this line, questions were solved related to its operating systems, its stability and automation. Consideration was given to the particular features of the given 750-kv power transmission related to its position, significance for the connected power systems and possible consequences from disturbances of stability.

The development of the OES of the South and the operating regimes of the 750-kv power transmission. In the OES of the South, primarily large thermal power plants have been built with the installation of units having a maximum unit capacity of from 100 to 800 Mwt. In 1970, two-thirds of the generating capacity was concentrated at 10 stations with block units of 200-300-800 Mwt.

During the first stages of developing the OES of the South, a voltage of 220 kv was set as the highest voltage stage for the intersystem hookups.

At the following stage, voltages of 330 and 500 kv were examined, and the advisability of introducing a voltage of 330 kv was established.

However, in introducing a voltage of 330 kv, it was considered that by 1970-1972, the basic lines of this voltage

would be converted into distributor ones and could not perform the functions of intersystem hookups. Analysis of the development prospects of the OES of the South showed that since this system could not expect stably routed and long-term capacity and power return flows between the individual regions, the necessary capacity of the intersystem hookups could not be determined solely by the balance capacity flows. It was also essential to consider the return flows of capacity determined by the deviations of the actual load increase and the introduction of capacity from the calculated, by the two-way exchange of emergency reserve capacity of the individual power systems comprising the OES of the South, as well as other factors. In the given instance, the return flows not related to the capacity balances are comeasurable with the balance ones and can significantly exceed them. Analysis of the individual components of the calculated capacity return flows established the necessary capacity of the intersystem hookups in the OES of the South for the 1975 level equaling 2-3 million kw. For providing such capacity, the following variations were provided for the development of the networks: strengthening the 330-kv networks; introducing a voltage of 500 kv; introducing a voltage of 750 kv.

Technical and economic analysis of the variations showed that maintaining a voltage of 330 kv as the highest, without having economic advantages over the other variations, at the same time possesses considerable technical drawbacks (the complexity of laying the routes of a large number of parallel lines, the greater readings of the short circuit currents, the difficulties of connecting large power plants to the system and so forth);

A voltage of 750 kv, in comparison with 500 kv, even at the first stage (5-6 years) will provide a savings that is small (3-5 percent) but steady (with a variation in the real limits of the initial data), and is most successfully combined with the existing voltage of 330 kv and is more prospective.

The state of the scientific and design studies on 750-kv equipment as well as the results of operating the first models of equipment installed on the experimental Konakovo--Moscow 750-kv power transmission line has made it possible to complete the first industrial 750-kv lines and substations at the established times.

In addition to the designated variations, a study was also made of a voltage on the order of 1,000 kv and the building (instead of introducing a higher level of voltage)

of a direct current power transmission line connecting 2 or 3 basic units of the system.

It was discovered that the introduction of lines using a voltage on the order of 1,000 kv of alternating current was not advisable, since with the great load density in the OES of the South there would inevitably be a lrage number of high-voltage substations. Even with a minimum number of substations (four), this variation did not possess economic advantages in comparison with a voltage of 750 kv. The reliability of the 1,100-kv variation was less, since for a significantly longer time, the basic hookups would be single-circuit. The building of direct current power transmission lines is less economic and does not exclude the introduction of a higher voltage of alternating current. Due to the designated considerations, it was decided to use 750 kv of alternating current as the highest stage.

In building the system of the 750-kv networks over the long run, consideration was paid to the configuration and size of the territory of the OES, the sizes of the adjacent OES and the hookups with them, as well as the characteristics of the individual units within the OES.

The largest adjacent associations of the OES of the South were the OES of the Center and the other OES connected to it as well as the Unified Power System of the CEMA member nations (the Peace OES).

Proceeding from the particular features of the external hookups, during the first stage of developing the 750-kv networks in the OES of the South, it was decided to create 750-kv power transmission across the entire territory of the system through its central part running from east to west (Fig. 1) (during the first stage, one circuit, and subsequently two or more). The first 750-kv circuit should follow the shortest distance to hook up with the connecting points of the associations adjacent to the OES of the South in the west and east, as well as interconnect the largest units within the OES of the South (Donets Basin -- Dnepr -- Vinnitsa -- L'vov). For connecting the remaining regions of the OES of the South, for a long time to come, in a majority of instances, a voltage of 330 kv will be sufficient, since the distance from the intermediate points on the 750-kv Donets Basin -- L'vov main line to the boundaries of the system in the south and the north does not exceed 330-400 kilometers.

For a certain period of time until the creation of a developed network of 750 kv, this power transmission line

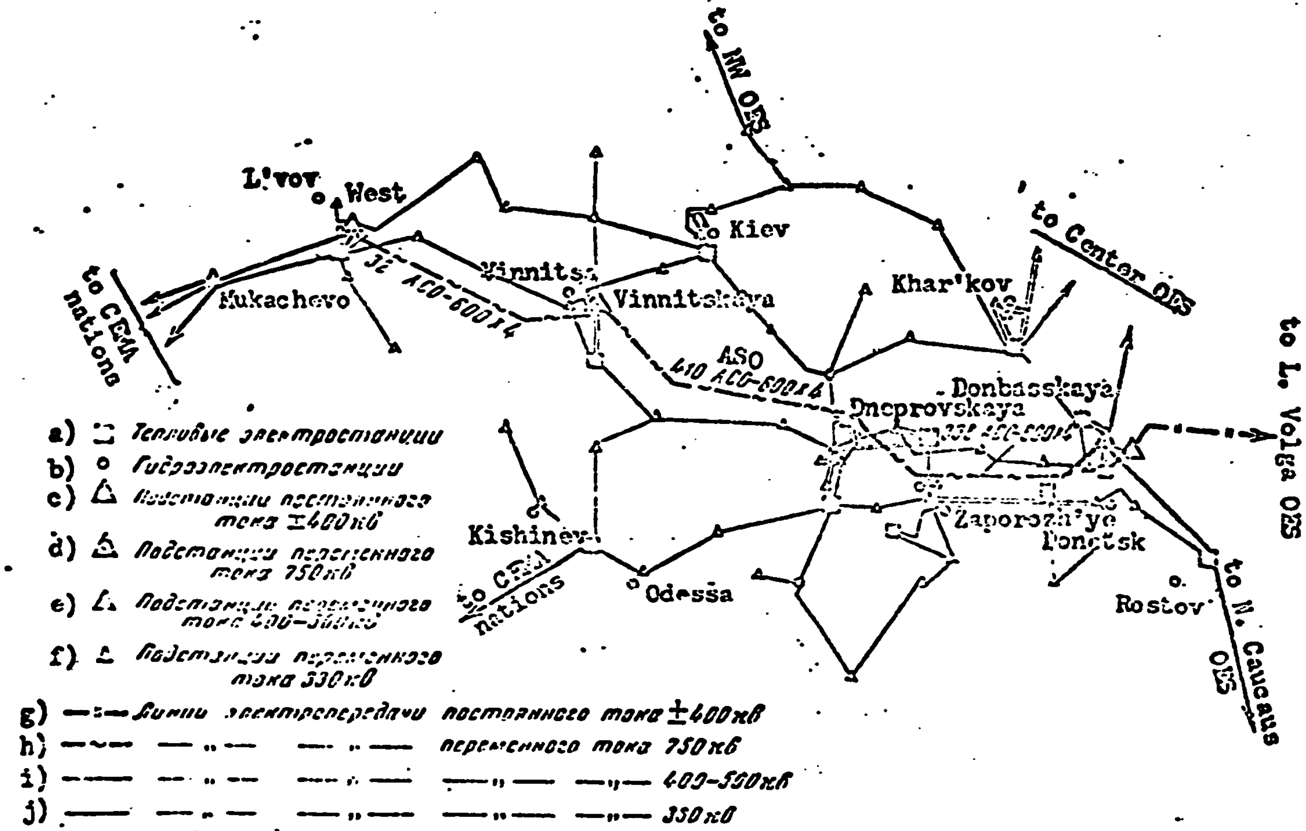

Fig. 1. Long-range system of the basic networks of the OES of the South during the first stage of introducing a voltage of 750 kv.

[Key: a -- thermal power plants; b -- hydroelectric plants; c -- DC ± 400-kv substations; d -- AC 750-kv substations; e -- AC 400-500-kv substations; f -- AC 330-kv substations; g -- DC ± 400-kv transmission line; h -- DC 750-kv transmission line; i -- AC 400-500-kv transmission line; j -- AC 330-kv transmission line.]

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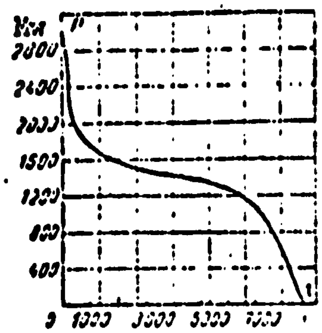

Fig. 2. Calculated schedule of the duration of exchange capacity flows.

The stability of the power association and 750-kv power transmission. Research on the stability of the association was carried out for the intersystem and basic intrasystem hookups. The 750-kv power transmission line is the greatest power hookup between the eastern and western portions of the OES of the South. For this reason, rigid demands were made upon its stability in terms of the entire range of supposed operating systems. And for the protracted systems (more than 500-1,000 hours) these demands were more rigid than for the short-term, that is, in accord with [1], in determining the stability requirements, consideration was paid to the significance of the transmission and the probability of the system.

Stability research on the designated 750-kv Donets Basin -- L'vov power transmission line, under the conditions of the parallel operation of the OES of the South with the OES of the Center and the OES of the CEMA member nations, particular features were discovered which, obviously, will largely be characteristic for other high-capacity intersystem connections. For the given line, the most difficult in terms of stability is the system of the winter maximum whereby the transmission of power from the east to the west reaches the greatest amount. This system was used as the basis for the stability calculations.* The stability and special measures for raising it were evaluated in the entire expected range of return flows.

The calculated systems for changing the network of the OES of the South contained up to 30 units and 18 equivalent generators. The generators were accounted for by a constancy of the transient emf, while the loads were accounted for by

* The stability calculations were basically carried out on an Ural-4 digital computer according to the program described in [2].

the constant resistances. Research of the influence of the methods of presenting the loads on the static stability showed that with the possible changes in the load characteristics, the maximum capacity for power transmission changes by only 5 percent.

Let us examine the particular features of the analyzed system which are determined by the enormous capacity of the power association.

With short circuits in the 750 and 330-kv network disconnected by the basic safety relays, the dynamic stability, is maintained without employing any additional measures, since the inertia of the system is very great. However, for providing synchronized dynamic stability with short circuits close to the buses of the large power plants, in a number of instances the primary units of these plants must be effected.

The relatively high level of synchronous dynamic stability is determined by the fact that the capacity imbalance occurring with a short circuit, in terms of the capacity of the OES, is insignificant and the dynamic transfer remains stable. For this reason, in terms of the stability condition, there is no need for greater speed of the safety relays and switches and a reduction in the pause of the BAPV [high-speed automatic recloser] on the 750 and 330-kv lines, with the exception of the areas of the network connecting large plants with the power system.

The power surges caused by the disconnecting of large blocks are not dangerous for the designated system. For example, disturbances caused by the shutting down of three 200-Mwt blocks or two 300-Mwt blocks in the western portion of the OES or an 800-Mwt block in its eastern portion, do not exceed the normed [1] reserves of static stability in the pre-emergency systems.

Research has shown that basically the static stability is disturbed with the exceeding of its limit in the post-emergency system (with a faulty APV [automatic recloser] on one of the sections of the 750-kv VL [overhead line]) or with an asynchronous system on the adjacent sections. The stability of the system in the postemergency operation (after disconnecting the sections of the 750-kv VL) can be raised by using automatic safety equipment which limits the return flows on this section for the 330-kv lines remaining at work to a value corresponding to the necessary reserve of static stability in the postemergency system. The systems automatic equipment under these conditions has a significantly greater role

should operate in parallel with the network of 330 kv. Since the capacity of the 330-kv networks shunting the transmission of 750 kv is commensurable with its capacity, the operating regimes of the Donets Basin -- L'vov 750-kv power transmission line were provided jointly with the operating regimes of the 330-kv networks.

Analysis of the capacity balances of the individual regions of the OES of the South for a period up to 1975-1978 showed that:

The value of the maximum balance return flows over the 750-kv line varies from 1 million kw (the section Dnepr -- Vinnitsa -- L'vov) to 2 million kw (the section Donets Basin -- Dnepr);

The directing of the return flows over the year can be stable (the Donets Basin -- Dnepr section) as well as reversible (the section Dnepr -- Vinnitsa -- L'vov);

Over time, depending upon the date and rate of completing the capacity, the value and the direction of the return flows according to the sections can change, and here it is expected that in the Donets Basin -- Dnepr section, the directing of the flow from east to west will remain for a long period of time.

The return flows change in time, in direction and within broad limits, depending upon a combination of a number of factors. An evaluation of these return flows by probability methods has shown the necessity of considering return flows of not less than 1-1.5 million kw in the capacity and these may coincide in direction and in time with the balance return flows.

Thus, on certain sections of the 750-kv power transmission line, in 1975-1978, there is a possibility that capacity return flows may arise of around 3 million kw.

Fig. 2 gives a duration distribution of the expected capacity flows between the Donets Basin and the Dnepr systems. From this graph we can see that return flows of 2,000-3,000 Mwt are expected for only around 3 percent of the time, and from 1,000 to 2,000 Mwt, around 80 percent of the time. These date have been used as the basis of determining the electrical systems and the requirements upon stability and automation.

placed upon it than ordinary, namely maintaining the stability of the power association under a number of operating systems in the postemergency system (after the disconnection of the 750-kv line). The increased demands upon the automatic equipment in the given instance are justified, since the operating systems under which the stability of the system in the post-emergency operations is achieved solely by the action of the automatic equipment are comparatively rare.

The table shows that the maximum capacity for the 330-kv connections remaining in operation after the disconnecting of the 750-kv VL vary for the three sections. This has been caused by the differing approach to maintaining stability with the disconnecting of the 750-kv VL on the Donets Basin -- Dnepr section and on the Dnepr -- Vinnitsa -- L'vov sections.

Power transmission section	Donets Basin -- Dnepr	Dnepr -- Vinnitsa	Vinnitsa -- L'vov
Number of 330-kv shunting connections on section	5	3	3
Total maximum transmittable capacity over the 330-kv lines with the disconnecting of the 750-kv VL on this section, Mwt	3,900	1,800	1,800
Same in percent of total limit of transmittable capacity with connected 750-kv VL	50	45	55

On the Donets Basin -- Dnepr section (sufficiently powerful shunting 330-kv connections) for preventing a disturbance of stability with the disconnecting of the 750-kv VL, there must be an unloading of transmission which can be achieved by the high-speed emergency controls and by limiting the capacity of the thermal power plants (Donbassenergo [Donets Basin Power Association]) and simultaneously by disconnecting (Dneproenergo [Dnepr Power Association]) the consumers which can allow a brief interruption in power. It is most advisable to shut down the load and unload the plant to the same degree. Here, the reduction in the power transmitted on this section does not influence the operating regime of the adjacent sections and the frequency of the power association.

It is advisable to limit the power on the 330-kv lines in several stages (for example, by 400, 800 and 1,200 Mwt) in

shutting down the 750-kv VL, depending upon the preceding capacity for the 750-kv VL. If the necessary quantity of load permitting an interruption in power has not been accumulated for unloading the line in the systems of maximum power transmission, it is possible to reduce the return flow of additional unloading of the plants in Donbassenergo. Approximately (with close equivalent coefficients of statism for parts of the association located to the west and east of the Donets Basin -- Dnepr transmission), the achievable reduction of power transmitted on this section will be:

$$\Delta P = \Delta P_g \frac{P_1}{P_1+P_2} + \Delta P_1 \frac{P_2}{P_1+P_2},$$

where ΔP -- the reduction in the transmitted power; ΔP_g -- the reduction in the power of the generators in the transmitting system, ΔP_1 -- the reduction in the load capacity in the receiving system; P_1 -- total capacity of the receiving portion of the association located to the west of the designated transmission; P_2 -- the same for the transmitting section of the association located to the east.

The relatively slow increase in the reciprocal angles between the vector of the emf of the stations, in disconnecting a portion of the 750-kv VL, makes it possible to effectively disconnect the consumers for a time exceeding the pause of the BAPV. Thus, this automatic equipment will operate only in the event of falsy BAPV, and under systems accompanied by the transmission of significant power over the 750-kv VL. For reducing the power interruption of the disconnected consumers, it is advisable at the same time to switch the hydrogenerators of the Dneproenergo stations from a compensatory system to an active one, and switch on the reserve units.

On the Dnepr -- Vinnitsa and Vinnitsa -- L'vov sections, the shunting 330-kv connections are comparatively weak, and for this reason, with an outage of the 750-kv line, the parallel operation of the power associations for the three extended 330-kv lines should be maintained under operating systems, where the power flows over the 750-kv VL are relatively small and approximately correspond to the planned balance flows ($T_{max} \approx 5{,}000$ hours). With the outage of the 750-kv VL under the operating systems of transmitting brief large flows ($T_{max} \approx 500$ hours), on the shunting 330-kv lines the breaker automatic equipment should be used which should disconnect these lines with a faulty BAPV of the 750-kv VL, so that the asynchronous passage not cause a disturbance in the stability of the adjacent systems.

The safety system automation. The safety system automation was reviewed for 1973-1975.

On the 750-330-kv connections of the Donets Basin -- Dnepr, with brief systems of transmitting power flows over the 750-kv VL up to 2,000 Mwt with $T_{max} = 500 \div 1,000$ hours, the safety system automation has been designed for preventing a disturbance in stability with an outage of the 750-kv VL by unloading the designated connections through limiting the power of the thermal power plants and disconnecting the consumers.

Under the systems using the Donets Basin -- Dnepr 750-kv VL to transmit balance power flows up to 1,200-1,400 Mwt with $T_{max} = 5,000 \div 6,000$ hours, the safety system automation has basically been designed for preventing a disturbance of stability, with severe damage to the 750-kv VL related to the faulty operation of the switches and the action of the UROV [abbreviation unknown], as well as with damage to the 750-kv VL under the systems of repair outages of one of the basic 330-kv shunting connections.

The starting automatic equipment for the 750-kv power transmission line has a three-stage power control for the 750-kv VL in the preceding system and in operation, with the tripping of the safety relays and the disconnecting of the switches on both ends of the transmission.

The use of graduated control of the preceding capacity of the 750-kv VL makes it possible to approximately estimate the load of the intersystem 750-330-kv hookups on the Donets Basin -- Dnepr section, and to carry out, if possible, a differentiated action of the safety automation depending upon the size of the return flow.

On the 750-kv power transmission line, they also plan to use starting automation equipment reacting to a change in the angle between the voltage vectors on the 330-kv buses of the 750-kv substations (Donbasskaya and Dneprovskaya). This automation makes it possible to directly establish a disturbance in stability on this section. The setting of the automation for the angle should be devised from the reciprocal angle for the transmission with short circuits on the 750-kv VL with a properly operating APV or OAPV [single-phase automatic reclosing], as well as with damage on the adjacent sections of the 750-kv transmission. Stability research has shown that the designated transmission angles do not exceed 50-60°, and a further increase in the angle to 150-180°, with a stability disturbance occurs over 2.5-9 seconds. Since

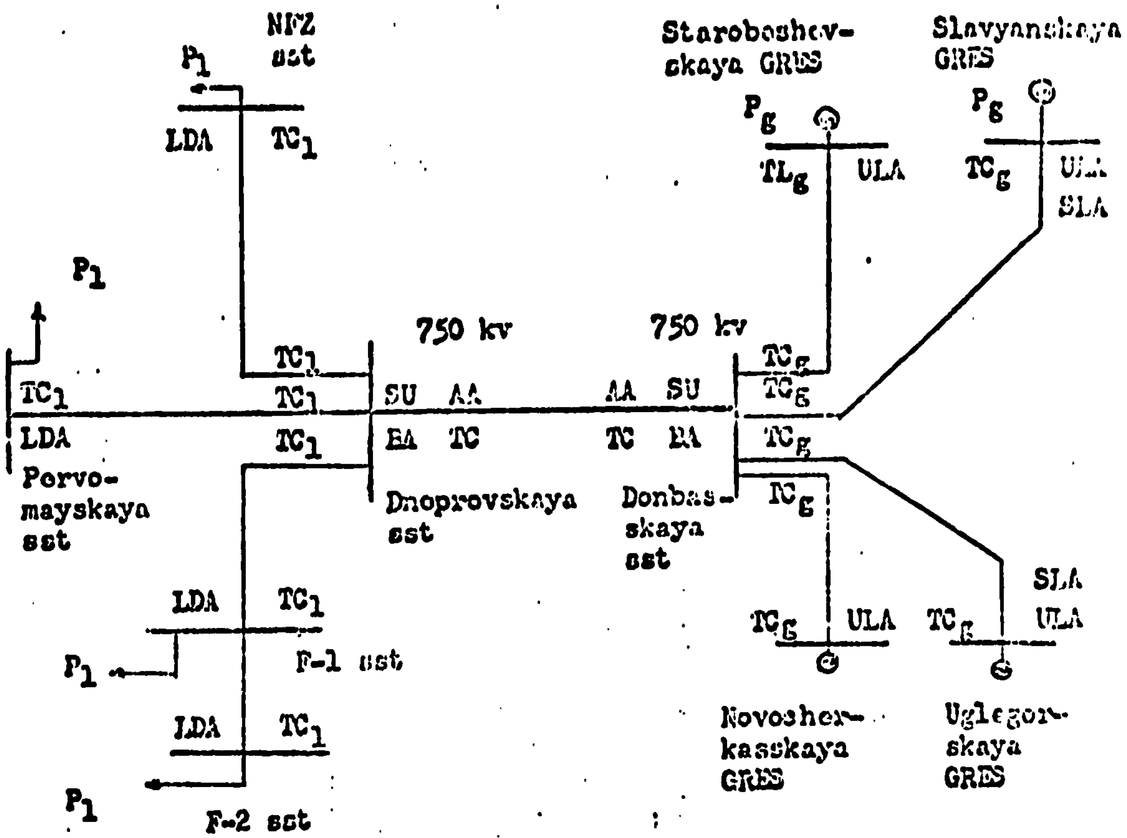

Fig. 4. Diagram of the placement of automatic safety equipment for the Donets Basin -- Dnepr 750-kv power transmission line.

P_g -- station generators; P_1 -- load consumers; SU -- automatic starting units with graduated power control for the 750-kv line and starting with the activating of the safeties or the disconnecting of the switches; AA -- angle automatic unit; BA -- breaker automatic equipment; TC -- teletransmission signal unit of safety automation; TC_1 -- signal teletransmission unit for load disconnection; TC_g -- signal teletransmission unit for fall in generating capacity of station; LDA -- load disconnecting automatic equipment; ULA -- high-speed automatic equipment for unloading and limiting station power; SLA -- starting units for local station automation for high-speed turbine unloading with nearby short circuits.

On the sections of the Dnepr -- Vinnitsa and Vinnitsa -- L'vov 750-kv power transmission line, the safety automation will be based on the same principles as for the Donets Basin -- Dnepr section, but with certain particular features.

The safety system automation has been designed for a reversible power transmission.

With return flows for the Dnepr -- Vinnitsa -- L'vov transmission not exceeding the planned balance values (T_{max} = 5,000 hours) no measures are required to prevent stability disturbances with the disconnecting of the 750-kv VL. Since the 330-kv shunting connections on the given section are weak, with brief power flows which significantly exceed the balance and the disconnecting of the 750-kv VL, their rapid separating is provided.

In the systems of Kiyevenergo [Kiev Power Association], Vinnitsaenergo [Vinnitsa Power Association] and L'vovenergo [L'vov Power Association], there are no major concentrated consumers which will stand a brief interruption in power supply. For this reason, the high-speed disconnecting of the consumers using the safety system automatic equipment in these systems, with a disconnecting of the 750-kv transmission, has been planned using frequency circular remote control for disconnecting the consumers which are connected to the AChR [frequency-controlled unloading].

As the reserve automatic safety equipment on the 750-330-kv connections, breaker equipment has been provided designed to operate in those instances when a stability disturbance and the occurrence of asynchronous regimes cannot be prevented by the above-examined automatic safety equipment.

In choosing the breaker equipment for the 750-kv power transmission line, consideration has been paid to the following requirements:

Dependable operation with asynchronous regimes on the given transmission and keeping out asynchronous regimes on adjacent sections;

Reserve capacity with breakdowns of the automatic breaker sets on one of the ends of the VL;

Detection and elimination of an asynchronous course in the incomplete phase systems related to the failure of the switches of one or two phases;

Providing as rapid as possible breaking, since the asynchronous systems are accompanied by long voltage falls on the 330-kv buses of the large stations and major juncture substations.

the stability disturbance occurs sufficiently slowly, the single use of the starting equipment of the automation is effective (Fig. 3).

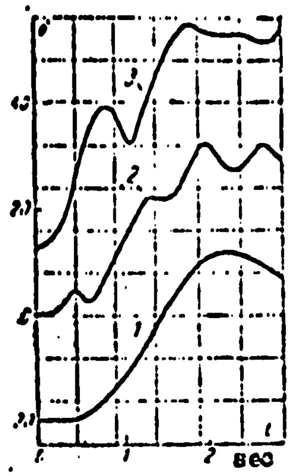

Fig. 3. Angular change between equivalent generators of the Peace OES and L'vov (1), Kiev (2) and Donets Basin (3) with faulty BAPV on the Donets Basin -- Dnepr 750-kv line.

Aside from the designated automation, at the large thermal power plants with blocks of 300-800 Mwt connected to the substations of the 750-kv power transmission line, for example, the Slavyanskaya and Uglegorskaya GRES [state regional electric power plant], for preventing a disturbance of the dynamic stability, plans have been made to use automation with starting when the 330-kv safeties are activated and with a significant fall in the direct sequence voltage (less than 0.5-0.6 U_n) on the 330-kv buses of the designated GRES with control of the preceding capacity of the plant.

For transmitting the signals of the safety automation on the 750-kv power transmission line, very dependable and high-speed high-frequency channels are required for the 750-330-kv VL as well as over the cable communications lines using high-frequency and voice frequency remote disconnecting equipment. For increasing the reliability of the safety automation on the basic routes, plans have been made for duplicating the communications channels and equipment. A diagram of the location of the system safety automatic equipment of the Donets Basin -- Dnepr 750-kv power transmission line is given in Fig. 4.

On the 750-kv power transmission line, as the basic equipment they have planned automatic angle breaking equipment with a set of around ± 150° making it possible to dependably detect a stability disturbance in the first cycle.

For providing mutual reserve capacity, a plan to install a relay for angle measurement on both ends of each of the sections of the 750-kv power transmission line is provided. In accord with the stability research, with the given settings, the automatic breaker equipment has been separated from the maximum 750-kv transmission angle with damped fluctuations in the event of emergency turbine control, as well as with stability disturbances on related sections. As additional equipment on each of the ends of the 750-kv power transmission line breaker units have been installed with starting units activated by the current or the alternation of the sign of the active capacity with a counter of 2-3 cycles and an additional time delay and a controlled resistance relay for controlling the position of the center of fluctuations on the 750-kv VL, as well as with starting units reacting to a pulsation in the current of the zero sequence in an asynchronous incomplete phase regime and with a time delay. The systems testing will tell which of these types of breaking is preferable.

On the 330-kv shunting connections for breaking in the first cycle, breakers have been planned with starting units reacting to the rate of change in the measured resistance.

In addition, on the shunting 330-kv connections, they also plan to install breakers with a counter of 2-3 cycles of an asynchronous course as well as units reacting to the pulsation of the zero sequence current.

Conclusions. 1. The first element of the 750-kv network, the Donets Basin -- Dnepr -- Vinnitsa -- L'vov 750-kv power transmission line, creates an opportunity to connect in tandem the associations of the Center and South with the association of the CEMA member nations, as well as to produce capacity from the new power plants with blocks of 300-800 Mwt.

2. The disconnecting of the 750-kv power transmission on one of the sections (without the APV or after the unsuccessfull BAPV) in a number of instances is a severe disturbance of the system, and here the stability is maintained only by using the system automation. This causes increased demands upon the automatic safety equipment in terms of its selectivity and reliability.

3. The high-capacity 750-kv power transmission has a significant influence upon the regime and stability of the power association as a whole. A disturbance in stability on one of its sections leads, as a rule, to significant voltage falls in the 750 and 330-kv network and to stability disturbances at the individual power plants. The basic task of the system automation is to prevent such stability disturbances or to localize them.

4. The research conducted has made it possible to determine the necessary range of systems automation and to evaluate its effectiveness in providing the necessary level of stability in the system. This automatic equipment should combine widely used equipment (BAPV, APV, and so forth) with comparatively new equipment (emergencey regulation of steam turbines, load disconnection in the function of the transmission angle).

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HIGH-VOLTAGE UKRAINIAN POWER LINE DESCRIBED

[Article by Engr V. S. Zheleznyak: "750-kv Power Transmission Between the Donets Basin and the West"; Kiev, Energetika i Elektrifikatsiya, Russian, No 3, 1971, pp 7-9]

The first industrial 750-kv power transmission line between the Donets Basin and the West consists of three sections: Donets Basin -- Dnepr -- Vinnitsa -- West, with substations in the regions of Donetsk, Dnepropetrovsk, Vinnitsa and L'vov. Over this line around 1100 km long, they intend to transmit long-term power flows of 0.7-1.7 million kw, and short-term ones to 2 million kw.

The 750-kv power transmission line will be a unique electrical bridge for maneuvering electric capacity in the southern OES [united power system] and in the CEMA nations. Via the Donets Basin substation with a voltage of 500-kv there will be a hookup with the OES of the Center and Northern Caucasus, and through the Western Ukrainian Substation, with a voltage of 400 kv, a hookup with the power systems of the CEMA nations. In line with the growing scarcity of peak capacity in the Southern OES considering the time difference over such a great distance from east to west, it is possible to use the discrepancy in the load maximums and during the winter convert the Volzhskaya and Severo-Kavkazskaya hydroelectric stations to a peak operating system.

The line has been designed for metal bolted zinced supports. The intermediate supports are portal on bases with a height of 32 meters from the ground to the traverse.

On individual crossings they are free-standing portal ones. The anchor angular supports are triped with an additional support for bypassing the loop.

The insulators are glass. The support garlands are double-chain with 24 PS-12A insulators in each chain. On areas of the route in the fourth region of icing, a portion of the support garlands is of 38 PS-16B insulators. The tension garlands are four-chain with 34 PS-22A insulators in each chain.

The power transmission line uses ASU-400 wire with four strands in a phase with a split spacing of 600 mm, and interphase distrance of 19.5 meters and two ferroaluminum cables of the ASKUS-70 grade.

The cables have been insulated and are used for high frequency communications. The insulating level of the cables has been set proceeding from the conditions of melting ice on them with a voltage of 110 kv.

The choice of the line phase parameters has been made considering the restriction of maximum tension of the electric field on the surface of the wire according to the tolerable level of radio interference from the corona.

In choosing the route, consideration was given to the necessity of locating it as close as possible to the boundaries of the crop rotation fields, and the impossibility of coming not within 120 meters of population points and 80-100 meters for separate houses. Moreover, an effort was made to reduce the number of crossed railways and highways as well 35-330 kv power transmission lines.

In four points of this transmission line, in the regions of Artemovsk, Dnepropetrovsk, Vinnitsa and L'vov, it was planned to build substations with a higher voltage of 750 kv and a lower one depending upon the existing, as follows: 750, 500 and 330 kv at the Donets Basin substation, 750, 400 and 330 kv at the Western Ukrainian; 750 and 330 kv at the Dnepropetrovsk and Vinnitsa ones.

The total transformer capacity of the substations is 5500 mva at the Donets Basin substation, 3000 mva at the Dnepropetrovsk and Vinnitsa ones and 5000 mva at the Western Ukrainian substation.

Due to the great length of the sections, under no-load conditions for the line, the necessity has appeared of consuming significant surpluses of reactive power generated by the lines. The amount of this power is 600-700 mvares. For compensating for this power, provision has been made for installing, on each section of the line, two 300-mvare reactors connected to the beginning and end of the line section. The connecting of the reactors to the line is planned through a special device (cut-off) with a spark connection with overloads and its disconnecting under conditions of transmitting large flows of power over the 750-kv line.

Under maximum load conditions on the 750-kv line, at the 750-kv substations it has been necessary to install additional sources of reactive power. At the reactive power sources provision has been made to use synchronous compensators with a capacity of 160 mvares each connected to the tertiary winding of the 750/330 kv autoformers. At all the 750-kv substations, provision has been made for arranging voltage cross regulation. The voltage cross regulation of the 750/330-kv autoformers will be carried out by activating a special control transformer in the breaking between the brought out neutral of the autoformer and the adjustment winding built into the autoformer for the longitudinal adjustment (made in the zero of the autoformer).

The system of the 750-kv ORU [open distributor] at the substation is one and a half. On the 750-kv ORU, in the connection circuit, provision is made for the insulation of instrument current transformers of the TRN-750 type, and capacitance voltage breakers of the NDE-750 type.

As switching equipment at the substations, provision has been made for the installation of a new type of switches, the VVB-750, with quencher chambers in metal tanks, and by this complete protection against explosions in the switches is achieved.

On the 330-kv ORU, there is also a one and a half system. In all circuits of the connections, switches of a new type, the VVB-330 have been installed (since the VVN-330 are not sufficient in terms of deflecting capacity), breakers of the RND-330 type, and for the instrument current transformers the type TFKN-330 has been used, and the voltage transformers are the NKF-330 type. At the substations, provision has also been made for the melting of icing: with a voltage of 110 kv on the cables of the 750-kv line, and a voltage of 35 kv on the cables of the 330-kv line.

For melting icing at the substation, a three-phase three-winding transformer has been used with 121 x 4 x 2.5 percent (37.5 ± 2 x 2.5 percent) 15 kv with a capacity of 80 mva connected to the 15-kv assembly of the first group of 750/330-kv autoformers.

For providing reliable work of the 750 and 330-kv switches with increased deflecting power values, provision has been made for complete compressor units consisting of three compressors at a pressure 230 guage atm., a productivity of three cubic meters per minute each, two high pressure air collectors with 230 guage atm., and three operating pressure air collectors at 40 guage atm.

The substations occupy 30-40 hectares of land each, and highways and railways will be brought up them. At them will be built the basic ORU for all voltages, the foundations for the autoformers and synchronous compensators, a general substation control point, a building for the auxiliary equipment of the synchronous compensator and enclosed 15-kv distributors. Of the auxiliary facilities, we must point out the combined building for repair and operating purposes, the compressor station, the air supply building, an installation for cooling industrial water, an insulating oil storage area, and so forth.

The autoformer groups are made up of single phase autoformers with a unit capacity of 333 mva each in phase with a single reserve phase.

In 1970, the Ukrainian division of Energoset'proyekt [Power Network Design Institute] completed the technical plans for the Donets Basin, Dnepr and Vinnitsa substations and the 750-kv line connecting them. The technical plans for the Western Ukrainian substation and the 750-kv line from it to the Vinnitsa substation have also already been completed.

In 1970, construction started at the Dnepr substation. In 1971, it is planned to begin operating its 330-kv distributor and the 750-kv line from to the Vinnitsa substation in order to temporarily operate it at a voltage of 330 kv.

At the same time, by the end of 1971, they intend to build and have in operation the 330-kv line between the Ladyzhinskaya GRES [state regional power plant] and the Vinnitsa 750/330 substation.

Considering the 330-kv lines which were completed in 1970 between Ladyzhin and Pobuzh'ye and Ladyzhin and Vinnitsa, this will be the third 330-kv line for delivering power from the Ladyzhinskaya GRES.

With the operating of the Ladyzhinskaya GRES at full capacity by the end of 1971, the Vinnitsa power system will have a surplus capacity on the order of 600,000 kw, and this surplus will decline by 100,000 kw annually.

Considering the nearly completed complex of the 330-kv line between Ladyzhin and Vinnitsa, the 750-kv line between Vinnitsa and the Dnepr and the 330-kv spur of the Dnepr substation as the most important project in 1971 for grid construction, Glavtsentroelektroset'stroy [Main Central Power Network Construction Administration] of the USSR Ministry of Power and Electrification has concentrated three trusts, the Southern, South-Western and Belorussian, on its construction.

The work sections have been distributed between the trusts, and they, in turn, have distributed them between the mechanized columns.

Simultaneously in 1971, at the Vinnitsa, Dnepr and Donets Basin substations, construction and installation work will be carried out, but this work is not part of the nearly completed complex related to the delivery of power from the Ladyzhinskaya GRES, but will soon be required for delivering power from the Slavyanskaya and Uglegorskaya GRES. The completion and operating of the entire power transmission line has been set for 1974. While the first section in the Soviet Union of a 750-kv power transmission line between Konakovo and Moscow running 90 km was a school for the designers, builders and operators, on the 750-kv line between the Donets Basin and the West, the acquired experience must be deepened and broadened.

The construction of the 750-kv power transmission line between the Donets Basin and the West is a matter of great state importance, and requires great attention and help for the direct executors by the party, Soviet and trade union organizations as well as all our community.

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ELECTRIC POWER TRANSMISSION EQUIPMENT DESCRIBED

/Article by I. S. Nayashkov, director of the All-Union Electrotechnical Institute imeni V. I. Lenin: "Soviet Electrical Equipment for the Transmission of Electric Power at the 'Elektro-72' Exhibit"; Moscow, Elektrotekhnika, Russian, No 6, June 1972, pp 13-15/

The constant growth of electric power transmission capacities and voltages has led to the broader use of power resources located far from the regions where the electric power is to be used. This growth requires improved parameters for the electrical equipment designed to transmit this power. These requirements are especially urgent in the large nations with rich power resources, particularly in the USSR, USA, and Canada.

The Volgograd-Moscow 500-kilovolt alternating current power transmission system has been in operation more than 12 years, the first experimental-industrial 800-kilovolt direct current Volgograd-Donbass system has functioned for 8 years, and the experimental 750-kilovolt alternating current Konakovo-Moscow link has operated for 4 years. Construction has begun on the 750-kilovolt alternating current Donbass-Zapad industrial link. This transmission line is approximately 1,100 kilometers in length. The design work and equipment production is proceeding on the Ekibastuz-Tsentr system that will transmit 1,500 kilovolts at a power of 6 million kilowatts. This line is approximately 2,500 kilometers long. The equipment is being developed for a 1,150 kilovolt alternating current LEP /electric power transmission line/. A considerable part of the equipment test models that will cope with this ultrahigh voltage has already been manufactured: an autotransformer, a discharge valve, and others.

The further increases in LEP voltages requires the resolution of a number of serious problems, particularly the decreasing of the overvoltage switching level, the creation of collapsible or semicollapsible structures for high-voltage transformers and autotransformers, synchronized switches and switches with preswitching resistors (predvklyuchennyye soprotivleniya), and new discharge valves with improved characteristics and increased capacities. Many scientific-research institutes and plants are now working on

many of these problems. The search is continuing for a method of transmitting electric power over high-voltage gas-filled and cryogenic cables. These devices and the means by which electric power will be transmitted in the distant future will be shown at the exhibit in the form of a three-dimensional diagram in the entrance hall.

The growth of electric power transmission voltages and capacities makes increased demands on the transformer builders. The models of 750- and 1,150-kilovolt autotransformers have already been created and in the near future the power of ultrahigh-voltage autotransformers will be raised to 1,600-2,000 megavolt-amperes in a three-phase group. An increase in the quality of electric power and the simplification of distribution networks require the wide introduction of transformers able to regulate voltages under load. This problem is being resolved at the USSR Ministry of Electrotechnical Industry's plants and at the VEI [All-Union Electrotechnical Institute] imeni V. I. Lenin.

Our nation's builders of high-voltage equipment ensure that the technical parameters required for the creation of powerful new LEPs are achieved. Test models of all the 750-kilovolt equipment have been developed. The VEI imeni V. I. Lenin is successfully developing a new series of air breakers to control 220, 330, 500, 750, and 1,150 kilovolts. The switching current will range up to 63 kiloamperes.

The soviet scientific research institutes and electrical equipment plans have accumulated a great deal of experience in developing and building air breakers for all voltages. The first domestic LEPs and substations for 500 kilovolts were equipped exclusively with soviet air breakers. The design and production of this equipment is always being refined. The Elektroapparat Plant has developed and produced the new series of type VVB air breakers with a modular arc arrester for voltages from 35 to 750 kilovolts. The latter has been the basis for the design and construction of a test model of a breaker for 1,200 kilovolts in a suspended state (podvesnoye ispolneniye). The 500-kilovolt model VVB-50-40/3200 breaker with a switching current of 40 kiloamperes is a standard representative of this series. It will be on exhibit at "Elektro-72." The control system employed in this equipment has made it possible to shorten the internal switching time from 65 to 35 milliseconds.

The Uralelektrotyazhmash Plant imeni V. I. Lenin has developed the type VNV air breaker with a double-breaker modular arc arrester for 220-250 kilovolts and is preparing them for production. These breakers function completely in no more than 0.04 seconds. Besides this, they are among the world's best in regard to their parameters and relative outlays of materials and compressed air.

The breakers designed for 110-220 kilovolts are being optimized. The Uralelektrotyazhmash Plant imeni V. I. Lenin has produced the first series of the types U-110-2000-50 and U-220-2000-40 oil-reservoir breakers. They are dependable, economical, and powerful and are respectively designed for 110 and 220 kilovolts with switching currents of 50 and 40 kiloamperes.

The design of these breakers is a great achievement for science and technology. The design made it possible to decrease the oil volume and weight of the breakers and increased their dependability, raised the number of allowed operations without inspection, and improved their parameters relative to the rated and disconnecting current.

In order to satisfy the demands made on the generator voltage equipment, the VEI imeni V. I. Lenin and the Elektroapparat Plant have developed and are producing type VV-20 generator air breakers for 20 kilovolts with a rated current of 12 kiloamperes and a switching current of 120 kilovolts. They have been installed at the Krasnoyarsk GES /Hydroelectric Station/, the Slavyansk and Konakovo GRESs /State Regional Electric Power Stations/, and at many other electric power stations. This switch will be exhibited at "Elektro-72."

The characteristics of the low-oil generator breakers of the types MG-10, MG-20, and MGG-10 have been improved. In particular, the rated current of the series MG breakers has been increased to 10 kiloamperes and the disconnecting current of the series MGG breakers has been raised to 58 kiloamperes. The type RVK-20 breakers and the type TShL-20 cast transformers which are conveniently built into enclosed busbar conductors have been developed for generator networks. Equipment for generator circuits is exported to many nations where it is used successfully, particularly in countries with tropical climates such as the Arab Republic of Egypt where such equipment has been installed at the Aswan GES.

In addition to this, developmental work is proceeding on new electrified gas, vacuum, valve, and synchronized air breakers. Development of small 110-kilovolt KRUs /complete distribution unit/ in grounded metal housings filled with electrified gas has begun. Their introduction will result in great savings of space and volume compared to the usual distribution equipment.

The discharger valve is the most important device to limit overvoltages and decrease the testing voltages of high-voltage equipment. The valves with Vilite and Tervite (tervitovyye) working resistances and magnetic arc arresters in the spark gaps that have been developed in our nation are successfully resolving this problem within the entire range of rated voltages. The type RVMK discharger protects equipment from lightning and switching overvoltages, and a test model for 1,150 kilovolts already exists. Types RVMG-500T and RVMK-750 high voltage dischargers will be shown at the exhibit. The type RVMG-500T magnetic discharge valve designed for 500 kilovolts in its tropical configuration is intended for the limiting of lightning overvoltages and has a breakdown voltage no higher than 2.5U$_o$ /translation unknown/ and a shielding ratio of no more than 2 with a 10-kiloampere current and a surge of 8/20 microseconds.

The type RVMK-750 discharger is designed to protect electrical equipment from lightning and switching overvoltages in network with a rated voltage of 750 kilovolts. This unit is approximately 8 meters tall.

Considerable success has been achieved in the development and production of discharge valves for our nation's 220-kilovolt networks. "Elektro-72" will have exhibits of the type RVT and RVRD magnetic discharge valves which possess protective characteristics equal to the best foreign designs. The type RVT-220 discharger is in series production and is designed to protect electrical equipment from lightning and momentary internal overvoltages. It features a shielding ratio of 1.7 with a 10-kiloampere current and weighs 666 kilograms. The unit is protected by a number of patents. The small type RVRD-220 discharger is interesting. It weighs 470 kilograms; the weight and size reduction was achieved as a result of an original decision in the design of a zigzag-shaped connection of internal components. A few patents were also registered on this discharger.

The further development of high-voltage equipment requires the assimilation and broad introduction of new materials and the improvement of the existing materials' characteristics. During recent years porcelain materials with high mechanical strength have been developed and their production begun. One-piece ceramic coverings with heights of more than 4 meters and base insulators with great mechanical strength have been produced. Their practical utilization has made it possible, for example, to decrease the weight of 220-750 kilovolt distribution units by 50-66 percent. Among the new materials that make it possible to increase the quality, durability, and dependability of high-voltage equipment are epoxy resins, high-quality electrotechnical fiber, glass-plastics, cold- and wear-resistant rubbers, viscous and nonspalling compounds possessing high dielectric properties and good adhesion, high-strength glues, and so on.

Domestic capacitor construction is developing rapidly. From 1946 to 1970 the output of basic power cosine capacitors increased 550 times. Practically all the necessary types of power capacitors have been developed and are in production and in 1958 the world's most powerful group of static capacitors began operation — the Kuybyshev-Moscow LEP's linear balancing installation.

The replacement of transformer oil with synthetic liquid dielectrics in power capacitors has allowed considerable increases in these installations' parameters. The further improvement of characteristics, especially the dependability of power capacitors, requires significant improvements in the quality of the paper, the liquid dielectric chlorobiphenyl, and aluminum foil and also requires the production of synthetic electrical-insulation films.

In constructing direct current power transmission facilities, especially the ultrapowerful 1,500-kilovolt LEPs, powerful capacitor units must be installed. These condensor units will function in a complex regime of reactive power compensation and highest current harmonic filtering.

Special damping and equalizing capacitors have been developed to ensure the normal operation of transformer units. Capacitors for capacitive-resistive high-voltage dividers and dischargers have also been developed for this purpose.

The Kondensator Scientific Production Association has developed the special DS-80-0.065 capacitors which are assembled into a column more than 4 meters high; the DM-80-0.002 models which are assembled into a column up to 10 meters high; the DMRU-80-0.01 and IK-100-0.025, both designed for 100 kilovolts with a capacitance of 25,000 picofarads; the 6.3-kilovolt KSSh-6.3-50 with a power of 50 reactive kilovoltamperes, and a number of other modifications. Almost all of them will be exhibited at "Elektro-72." These capacitors are the equal of the world's best.

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

APPENDIX 5a

E. Electric Power System Planning and Dispatching

ELECTRIC POWER AND RELATED EQUIPMENT

DEVELOPMENTS IN UNIFIED POWER SYSTEM DISCUSSED

/Article by V. Bereslavskiy; Leningrad, Leningradskaya Pravda, Russian, 4 April 1973, pp 1-2/

A bright spring day in Moscow. In the room of the Central Dispatch Administration of the USSR Unified Power System (TsDU YeES) blinds have to be drawn because of the sun. For a second the patches of sunlight can "erase" the image against the light blue background of the huge panel. Dispatchers' errors are ruled out here.

Several years ago our newspaper discussed the development of this panel and other equipment for the TsDU YeES by Leningrad engineers and workers. Then the entire complex was assembled in a building located in the center of Moscow not far from the USSR ministry of Power and Electrification. We will discuss below the circumstances that made us recall the old address, and now we will observe the work of people whose functions are to control Soviet power engineering. Figuratively speaking, we will listen to the country's power pulse.

Unified European Power System

Multicolored river lines are scattered over the mosaic floor of the control panel. These rivers are symbols standing for electric transmission lines of varying voltage. They flow in various directions, intersect, and fall one into another. Conventionally designated, the country's largest power stations are spread all over the floor. These stations, which are located in various regions of the Union, together with transmission lines and substations form power systems. These power systems are also designated on the panel. Each system is a unique sea of electric power. Thousands of industrial enterprises, agriculture, electrical appliances, and household mechanisms in our apartments derive power from these systems.

Here, in the control center, all the power systems are gathered on one panel and are in the field of vision of experienced dispatchers who at any time of day or night have their fingers on the country's pulse and, if necessary, immediately interfere in the operation of high-capacity power systems so that this pulse may be always efficient.

The development of a unified power system of the country's European part was completed at the end of the past five-year plan. It included high-capacity power systems in the Center, the South, the North-West, the Urals, the North Caucasus, the Central Volga, and the Transcaucasus. At one time each system absorbed developed regional power systems. Work on the development of a unified power system of the whole country is now being carried out on a wide front. Connection to the general ring of Siberia, the northern regions, and the Far East is next.

The reader may rightly ask why specialists adamantly want to unify all the systems into one. After all, each system in itself constitutes a vast power force.

"The point is that the country's various power systems are loaded differently during the same 24-hour periods," explains Vasiliy Tikhonovich Kalita, chief dispatcher of the TsDU YeES. "We constantly have situations where during peak hours some of the country's regions badly need power, while other regions have reserve power. Knowing this and being able to immediately control power transmission from one system to another, one can efficiently organize the operation of our entire power engineering.

"At present the unified power system includes 635 power stations of a total capacity of 127.5 million kilowatts. They produce about 75 percent of all the electric power generated in the country. They are vast power facilities -- an ocean of power in wires! How to dispose of such wealth in the best way?"

Morning. An ordinary work day. It is 0930 hours. The chief dispatcher opens the log. It contains several dozens of schedules. Here is the basic schedule. The day has to be organized according to it. The load line depicted on the lined paper something that greatly resembles... a camel back. Only two humps are slightly more pointed here.

"The first peak is precisely now, at an interval of 9 to 10 hours. Work has begun in enterprises and hundreds of thousands of mechanisms, instruments, and machines have been connected. Mariya Semenovna Volodina, the shift's senior dispatcher, is at the control panel, observing what is going on. Power consumption has jumped up. However, this is observed in the country's central regions. In the Urals and Kazakhstan peak loads are already over, while in the western regions they have not yet begun. Therefore, we can call on the capacities of these systems for help. In due course, when the next peak begins there, the center will share its electric power with them."

All the information on the operation of power systems, which altogether are a kind of circulatory system of the country's vast organism, flows through communication channels to the equipment room of the control center. Hundreds of parameters are recorded by equipment, analyzed, and processed by calculating and electronic computer equipment. The dispatcher can contact any regional administration by telephone.

The experience in the operation of large power systems showed that sometimes electricity can get out of hand. For example, this was the case in the United States in 1966, when, owing to several faults, the New York power system collapsed, or, as power engineers say, "was reduced to zero." This big city remained without electricity for many hours. Elevators stopped, holding their passengers in captivity, motors and machines bogged down in plants, and important continuous industrial processes were interrupted.

"Such situations are not possible in our country," says Eduard Vladislavovich Terskiy, the chief of the computer equipment service of the Central Dispatch Administration. "The whole unified system is equipped with thousands of devices which automatically cut off some consumers if the system is threatened with desynchronization. In practice, this will not cause any significant losses, because the auxiliary services of some enterprises and institutions will be temporarily discontinued."

By that time the work peak was over. At the dispatchers' command the power systems begin to reduce the capacities transmitted to the center. All this is done in accordance with the operating schedule prepared in advance on a computer by specialists. It takes into account literally everything: the weather forecast, the water level in rivers, illumination, the fuel quality, and the television programs...

"For example, in Moscow a sunny day saves up to 500 megawatts -- people do not turn on the light," says V. T. Kalita. "If Raykin, figure skating, or hockey is on the program, consumption jumps up by an average of 1 million kilowatts. An evening load peak is formed."

The preparation of such forecasts requires skill. However, the all-powerful equipment also comes to the aid of specialists in this case. Electronic computers read hundreds of drafts before an accurate forecast is given for the next day. Man assigns more and more problems to computers, teaching them this complicated work.

Giant Screen

The rapid development of Soviet power engineering sets for this sector ever more serious tasks. The capacities of units and stations increase and the systems comprising the unified power system possess an ever greater potential. This requires reliable communications among systems and the flow of information which has to be immediately processed and on which one can rely with assurance increases intensively.

"The work on the development of an automated system for the centralized control of the country's unified power system serves such goals," says Grigoriy Antonovich Chernya, the chief engineer of the TsDU YeES. "A whole set of measures will have to be implemented, that is, the buildings of the dispatch administrations of the country's largest power systems, as well as the Central Dispatch Administration of the Unified Power System, will have to be built, fitted with the appropriate equipment, and linked so that the optimum solutions could be made at any time."

The buildings of regional dispatch administrations are being built in Kiev, Sverdlovsk, Riga, Kuybyshev, Kemerovo, Tashkent, and other "power capitals." A building which will house the Central Dispatch Administration of the Unified Power System was built in Moscow. It will begin to be "occupied" by the most complex equipment in the very near future. The new control panel and consoles, which are being manufactured in Leningrad at the Elektropul't Plant and at the Fourth Furniture Combine, will most likely become the main sights of this complex.

We are in a spacious, as yet empty, room, where this equipment will be installed. Finishing work is now being done here, but this does not prevent Nikolay Petrovich Krasovitskiy, the deputy chief of the telemechanics and communication service of the TsDU YeES from discussing its features and function:

"First, the panel itself will be different. It will occupy twice as much space as the previous panel. Its dimensions are as follows: It is 7 meters high and 30 meters long. It will be made from more than 150,000 removable units."

The duties of this installation will change to a significant degree. Unlike its predecessor, the country's new main power screen will simultaneously reflect, so to speak, several aspects of the life of the unified power system. One part is assigned for almost the same mnemonic diagram as before.

Another part of the panel is a "mirror" of the operating conditions of various power systems. This "mirror" will reflect the extent of the overflow of capacities from one system to another, as well as deliveries to the CEMA countries linked by the Mir System.

The third part of the power screen is a built-in panel on which special motion picture equipment will project the necessary data and instructions on control problems. No one has ever developed a control giant panel so impressive in its dimensions and so technically perfect.

This also applies to the control consoles which can be included in the category of unique consoles. They are arranged in front of the p[illegible]l in a 13-meter arc, forming three work places for dispatchers. Behind t[illegible] the console of the chief dispatcher will be also placed in a semi-c[illegible]e on an elevation.

For the first time dispatchers will be able to use the so-called display system. A television receiver will be installed near every work place. The most diverse information, from reference to graphic information, can be output at will from the machine's electronic memory onto the screen of the television receiver.

In general, the set of equipment for the control center of the TsDU YeES developed by Leningrad specialists in cooperation with Riga, Penza, and Kutaisi specialists is an important technical step forward. It will make it possible to ensure the complete reliability, faultlessness, and convenience of all the processes of control of our power engineering.

Leningrad's Contribution

The conversation with Petr Stepanovich Neporozhnyy, the USSR minister of power and electrification, began in an unusual way. He pressed a button and a screen unfolded on the wall, displaying a large map of the country. The map came to life immediately. The signal panels on which the basic parameters of the unified power system at a given moment were designated lit up. The digital devices notched in the map in the places where various systems join and indicating the extent of the overflow of electric power from some of the country's regions to others began to blink. The pulse of the largest power system on earth was beating in the minister's office.

"We have learned to record on a global scale what takes place in Soviet power facilities. On this map and, of course, in a more detailed expanded form, on the country's main power screen in the Central Dispatch Administration of the Unified Power System one can see what the country's electrification is today. To be sure, however, no other national economic sector has such an acute need for developing an automated control system. In fact, the output generated by thousands of Soviet electric power stations should not be reserved somewhere, stored in a warehouse, or preserved. Everything that is produced should be immediately put to use.

"The nature of electricity requires the maximum efficiency from the people who control power engineering. Our scientists and designers are now doing extensive work on the development of the Energetika Automated Control System. The optimization of control processes will yield vast economic gains and centers for controlling the power systems that form part of the country's unified power system fitted with the latest electronic, telemechanic, and computer equipment are being established. All of them will be linked with the Central Dispatch Administration of the Unified Power System."

The minister comes up to the window. The new building of the Central Dispatch Administration -- a seven-story engineering block -- adjoins the ministry building. From here one can quite easily see the glass panorama of the room where the huge power panel and control consoles and thousands of the most complicated automation and communication devices will be installed in the very near future.

"Leningrad specialists are making a tremendous contribution to this work. The very fact that the development of the country's main power screen and of the basic control and automatic equipment was assigned to Leningrad, where they are already being developed, attests to this. However, Leningrad specialists are not merely developing a wonder diagram. I would like to stress that from the first five-year plans, from Volkhovstroy /expansion unknown/, from the first Soviet turbines and generators, and from the first plans for power engineering construction Leningrad scientists, engineers, and workers have most actively participated in the implementation of Lenin's precept: "Communism is Soviet power plus the electrification of the entire country."

The country's power development continues now at a higher rate than ever before.

Everything that is being done now in the laboratories of scientists and in plant shops will bring great benefits to our entire national economy, benefits which every Soviet man will feel.

Yesterday we telephoned Nikolay Mikhaylovich Golubev, the director of the Elektropul't Plant. This is what he told us:

"Our personnel attaches great importance to this work -- the development of equipment for the TsDU YeES. Socialist competition for filling the order ahead of schedule has developed. For the first time we will have to offload and assemble such complex equipment on the spot. The plant premises cannot hold such an installation.

COORDINATION OF ELECTRIC POWER AMONG NORTHWEST REPUBLICS

Riga SOVETSKAYA LATVIYA in Russian 30 Jun 74 p 4

[Article by I. Geyman: "A Lock on a Powerful River"]

[Text] No matter how tall the 100-year old pines at Shmerli were, even they were forced to respectfully bow their round tops to this building, which was recently erected in the forest massif. Reflecting the sky blue in its glass walls, it attracts the attention of passersby.

The proprietor of this building is ODJ [integrated dispatching control] for the energy systems of the northwestern Soviet Union. ODU means integrated dispatching control. In other words, this is a control center and a lock of a powerful electric river whose tributaries serve numerous electric power stations located in Karelia, Leningrad and Leningradskaya, Novgorodskaya, Pskovskaya and Kaliningradskaya oblasts, in Belorussia and the three republics of the Soviet Baltic area. Yet another steam will flow into this river this year -- from the Kola Peninsula. It not only has sources but a mouth as well: the electricity of the northwestern region flows through Leningrad and Belorussia to Moscow, becoming an integral part of the common electric power system of the Soviet Union. It also flows "for export" -- to Finland and Poland. Approximately 25 million persons live in the area where the ODU stations are located. Its area is 800,000 square kilometers. The scales are equal to a very large European country.

But is not this too enormous a task -- to combine control of tens of electric power stations and numerous power flows at a single location? Although it is cumbersome, this current development of power engineering is vitally necessary. Each republic and each oblast is now incapable of solving separately the problem of the balance of electric resources. Here is a small illustration: 70 percent of the electric power required by Latvia is obtained from outside, while in Estonia, on the other hand, there is a surplus of electricity -- it sends 60 percent of its resources outside the republic. Integration of electric power, regulation of its flows, provision of reliability of electric supply and reducing its cost immediately required powerful integrated electric power systems, and they required integrated

dispatching controls, which operate in a modern manner, using the latest equipment, rather than haphazardly in the old fashion. For the time being ODU of systems of the northwest is being located in Old Riga. It is crowded there and the shortage of buildings is felt more and more with each year. But the people live here literally in the past rather than in the present: construction of a new building is being completed at Shmerli, where control will soon transfer with its complicated facility.

If we speak more accurately, this is not a single building but an entire complex. The above-ground part of the structure is surrounded on three sides by a three-storey red-brick building, while, as if cut into it, there is still another semicircular building. Different both outside and inside, they nevertheless comprise a single whole.

This decision was not the whim of the architects of the Moscow Institute Teploelektroproyekt [All-Union State Institute for the Planning of Electrical Equipment for Heat Engineering Structures], headed by L. Braslayskiy. It is explained by the different requirements placed on each of the three buildings. The enormous dispatching room with automatic and telemechanics equipment is located in the semicircular building. Only three-four persons will work here simultaneously; therefore, the semicircular shape provides the best view of the numerous instruments.

The dispatching room is cut into the brick building because the eyes, ears and, most important, the brain of the entire control system will be located there. The ODU computer center with five of the latest third-generation computers with a very large communications terminal will be located here. This selection of equipment is explained by the fact that machines will take primarily upon themselves control of the electric flows and operation of the electric power plants after moving into the new complex. They will receive the required instructions through the communications channels and will know the power requirements at any point of the system -- all data will begin to be calculated at a speed inaccessible to man. Recommendations to the dispatcher will be issued here or one's own decisions will be made.

Its operating principle is in direct relationship to the purpose of this building. Here are the high rooms, air-conditioners, heavy roots: each square meter of the floor supports up to 1 ton of weight. A so-called false floor, consisting of small square plates, is installed above the common floor. Each of these plates is easily raised, providing rapid access to the complicated communications -- this is in case of malfunction. There is also a false ceiling, which covers the automatic fire-extinguishing system with radioactive sensors which react not only to an increase of temperature but to a specific smoke concentration.

This is the way the century has now passed -- excellent buildings are constructed not only for people but for machines as well. And this is justified: equipment is more and more taking on the functions which have long belonged to people, and more and more frequently it remains for man only to

press buttons. Incidentally, people should not grumble: a beautiful 12-storey "aquarium," which rises above the centuries old pines of Shmerli, has been constructed for them. It contains 10,000 square meters of total and 5,500 square meters of useful area.

The chief of ODU Yevgeniy Ivanovich Petryayev just recently returned from the United States, where he travelled in the company of a delegation of Soviet power engineers.

"I saw how the Americans control large electric power systems and, naturally, I compared them to our complex," he says. "I was again convinced: we do not have to gloss over anything -- we are confidently in step with the century."

The "shell" of the complex alone costs more then 3 million rubles. If one talks about the "filling," then it is even more expensive: the price of the set of equipment for a single third-generation computer is counted not even in tens and not even in hundreds of thousands of rubles. It is hardly feasible to invest such funds in a small enterprise even on a medium scale: wait until expenditures pay for themselves. And this is control of an electric power system....

Let us calculate a bit. The stations subordinate to the ODU, about which we are talking, produced more than 74 billion kilowatt-hours of electric power last year -- this is more than was produced in the entire Soviet Union in 1950. The volume of product sales (although you will not find them in the markets, but electric power is also a unique product) comprises 1.2 billion rubles annually. The new complex of buildings, together with its complicated and modern equipment of course will not provide an increase of electric power in itself. But it will permit an increase of the quality of its utilization and, in other words, will permit more rational expenditure of it and will permit a reduction of losses. Reduction of losses by only 0.5 percent will save 5 million rubles annually. This is how rapidly the invested funds will be repaid. And in this is the entire sense of generous expenditures.

...Separate operations are going on in all three buildings of the complex, which are being carried out by the collective of Daugavagesstroy [expansion unknown]. The builders are rushing: according to the plan this large object should be turned over during the current, decisive year of the five-year plan.

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TRANSMISSION OF ELECTRICITY WITHIN UNIFIED POWER SYSTEM

Moscow PRAVDA in Russian 9 Oct 74 p 3

/Article by Academician V. Popkov: "Electric Rivers of the Future -- Problems and Opinions"/

/Text/ Transporting power plays a noticeable role in the electrification of any country and the more so in the conditions of the USSR with its vast distances. Moreover approximately 80 percent of our power resources are concentrated in the east whereas the european part of the country is the chief consumer.

Soviet power engineering is faced with the grand-scale task of creating a unified power system (YeES USSR), which is not possible without supercapacity and superlong-range electric power transmission lines. The development of a complex of new high-voltage equipment with 1.5 million volts for direct-current and 1.15 million volts for alternating-current electric power transmission lines has been planned for the current five-year plan by the directives of the 24th CPSU Congress.

As for both power and voltage Soviet electric power engineering and the electrical industry have sound experience in creating and operating extraclass lines. And still the solution of the tasks set by the directives requires enormous efforts.

In power engineering the interdependence of the individual links in the unified chain -- from the energy resources to the electric power's consumer -- is manifested with exceptional sharpness. In other words, the serious energy problems cannot be resolved on a "district scale." Only a statewide approach makes it possible to evaluate correctly the importance and position of one solution or another against the background of trends in developing power engineering.

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In this connection I would like to dwell on the idea of "hydrogen engineering" being discussed in domestic and foreign papers. Using electric power generated by nuclear electric power stations (AES) located in the ocean is proposed for decomposing water into oxygen and hydrogen and delivering the latter through pipe lines like fuel to sites of consumption including "local electric power stations." Let us put aside using hydrogen as fuel for aviation, astronautics and ground transportation as a subject of a special discussion. As for electric power engineering's part in this project, its unfitness is pretty evident. Including a hydrogen link in the conversion cycle would lead to losses which would by far overlap possible losses in the direct delivery of power from an AES even over the most inadequate electric lines. The electric power fuel of the future is decidedly not hydrogen, but uranium and its derivatives to begin with for nuclear electric power stations and in the future deuterium and tritium for thermal nuclear electric power stations.

One has to hear that it is as if electric power transmission lines are losing their importance with the development of AES able to move power sources "as close as wanted" to centers of consumption. This is a peculiar reverse of the "district concept" of separate feeding, if only of the largest consumer.

The development of Soviet electric power engineering is going and undoubtedly will go further along another path,-- centralizing power supply to the maximum, creating extremely large stations and linking them with the centers of consumption by high-power transmission lines, right up to forming a united system of all the Soviet Union. Such a system, the YeES, has already been created in the european part of the country. It includes more than 500 electric power stations with an overall capacity above 100 million kilowatts located in the center, the south, the Caucasus, the Middle Volga, northwest and the Ural.

It should be emphasized that electric power transmission lines are not only a means of power supply and distribution, but they make it possible to exchange capacities between stations of the various regions, render mutual assistance in emergency situations, equalize load schedules, cover consumption "peaks" and utilize both power resources and different type stations efficiently. On the whole the consolidation of electric power facilities is ensuring high reliability and maneuverability of supply at minimum machinery capacity and under the most favorable operation conditions and in the end at the least cost if the machinery is considered on a statewide scale. Thus, apart

from other advantages, according to expert evaluations the formation of the YeES USSR is furnishing a saving of about 35 million kilowatts in the machinery capacity at the electric power stations.

The traffic capacity of this joining ought to be at least higher than 15 percent of the full capacity of the smallest of the power systems connected to it. It is not difficult to predict that power transmission lines will require a capacity of ten and then tens of millions of kilowatts in the near future with the creation of YeES USSR.

Electric power flows chiefly through overhead lines now. With all their shortcomings they are the most economically sound type of power transportation for the time being. Here the problem of establishing the electrical connection of the united systems of the east and european part of the country is most complicated. Covering distances of a 2,400-kilometer course -- from stations working on Ekibastuz coal to the center -- and then a 4,000-kilometer course -- from the Kansko-Achinskoye fields -- is being discussed. These are unprecedented engineering undertakings in worldwide practice.

As calculations show the Ekibastuz-center line will be extremely costly. And nevertheless, according to expert evaluations, the power at the receiving terminal will prove to be cheaper than that from GRES's /State Regional Electric Power Station/ in the european part of the country if they were working on imported coal. As we can see the first, the east-west, power river is resolving an important national economic problem. Subsequent direct-current lines from the Kansk and Achinsk basins will be even more long range and powerful.

The Ekibastuz transmission, the first on such a scale, is created on a principally new engineering basis. It required the special development of more than 60 models of equipment. Unlike the Volgograd-Donbass, the first industrial direct-current transmission, where rather capricious devices (the so-called "mercury" current converters) were used, the more perfect semiconductor (thyristor) converters will be used now. The use of higher voltage (1,500 kilovolts instead of 800), the provision of line reliability and so forth required special developing.

In this connection I would like to note that the Ekibastuz transmission is a necessary step toward creating still higher power and voltage lines. Jumping over this step without having accumulated experience would mean taking an unjustified engineering risk. Meanwhile the project, which was finished

almost a year ago, is still languishing in the depths of appraisal.

The creation of equipment for the over 2-million volt subsequent lines, as their installation, is a task of extreme complexity. It cannot be rationally resolved by simply transferring solutions already found for lower voltages. Thorough and lengthy (including laboratory) research with experimental voltages three to five times higher than the LEP /Electric Power Transmission Line/ "working" voltage is needed. We are not suggesting such potentialities as yet. You see, the draft of a complex of necessary high-voltage laboratories and stands does exist. And it necessary to consider in earnest if it makes sense to save resources by shelving this project's installation more than one year.

It is not out of place to recall that power transportation and distribution expenditures amount to 50 percent of the cost of installing electric power stations, which in just this link is a 20- to 30-percent loss of the total amount of power generated. Hence it is clear: as much attention must be provided for research in the area of electric power transmission as, for example, in the search for ways of improving its generation. Meanwhile the extent and level of the laboratory base, test stands, resources of developing search and theoretical work and the establishment of scientific work in progress along new directions and conceptions in the area of power transmission now seem to be the most neglected sector against the background of other power engineering divisions.

And here is another observation. It is as if the superlong-range direct-current lines are forming the skeleton of the YeES USSR. However this does not exclude, but suggests an excessive increase of alternating-current high-voltage power lines in the network evolved. They must bear the main load in the intrasystem and not-too-distant intersystem connections. The demand for such new lines is already arising now. A 750-kilovolt supersystem must be created in the south and northwest where 330-kilovolt lines are being joined. In the majority of the regions with 500-kilovolt networks 1,150-kilovolt LEP are needed for a substantial increase in the connections.

However in this instance the following must be discussed: the necessity of the serious development of research in many directions connected with the control of the wave processes in lines and with the study of the physical and engineering

aspects of the processes under superhigh voltages for which an experimental base is necessary again.

The present accepted means of transporting power are nearing the limit of their resources and it is time to think about the future. For the present two principal directions in reasearch are seen

The first is investigating the possibilities of surmounting the "potential barrier" for the growth of voltages in open-air devices. If up to now scientists have only "observed" how and when an electric discharge takes place under high voltage, they are now requested to seek ways of controlling these processes. The question is a task analogous in its internal content to an attempt to control the properties of lightning. It is not only a subject of engineering, but of fundamental research also. Evidently, the necessity of creating a special scientific institution for this research has come to a head.

The other way out is developing enclosed transmission. Here the perspective is to use gas-insulated lines in which the conductors carrying the current are placed in a tube filled under pressure with a special electrically "stable" gas. In principal such lines "according to their ability" should be for very high voltages and for enormous traffic capacity (up to several tens of millions of kilowatts) with small losses. The equipment of substations can be placed in a compressed gas atmosphere, which in this instance will take up a total of 10 percent of the area in comparison with open-air substations.

Experimental designs of gas-insulated lines and substations are being researched and developed already. In addition to that the necessity of the thorough research of electrical processes in compressed gases with different chemical structures for establishing the scientific principles of using gas insulation is clear.

It is impossible to throw out the possibility of using superconductivity, which opens the prospect of delivering enormous capacities -- up to hundreds of millions of kilowatts with extremely large currents and without too much voltage. However cooling the conductor with liquid helium up to 269 degrees centigrade is necessary for this and, of course, the design of such a line is not simple.

The physics of low temperatures would realize the dream of power engineering if a way could be found to create "warm"

superconductors able to retain superconductivity under heavy currents and if only at the temperature of liquid hydrogen (minus 253 degrees centigrade) and better yet of liquid nitrogen (minus 203 degrees). This would simplify the design and reduce the cost of "superconducting" lines.

Along with such fundamental problems a large number of other superlow temperature thermal and electrophysical problems require thorough research. The final goal is to find solutions capable of competing with the ordinary overhead lines. There is no doubt that the technology of power engineering will gain a secure rear area for further progress with the proper attention and appropriate equipment of scientific research.

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APPENDIX 5a

F. Superconducting Transmission Technology

PROGRESS IN DEVELOPMENT OF SUPERCONDUCTIVE TRANSMISSION LINES

[Article by E. Zuyev, Candidate of Technical Sciences: "Electrical Transmission Lines of the Future"; Moscow, Krasnaya Zvezda, Russian, 4 January 1970, p 4]

Only yesterday the possibility of utilizing low temperatures and superconductivity phenomena for increasing the degree of the economy of electric power installations was considered to be utopian. But technology never stands still. The development of economical methods of obtaining and transporting liquified gases, the discovery of new superconductive materials have placed the solution of this most important problem upon today's agenda.

Is it not too early to speak in such elevated tones about an infant which is still in the cradle? Are contemporary methods insufficient for the transmission of power on the scales of the next century? After all, at present in our country there is already functioning an experimental industrial electrical transmission line with the superhigh tension of 750,000 volts -- between the Konakovskaya GRES and Moscow. And scientists are attempting to increase the tension to 2,265,000 volts.

Along such an overhead line it would be possible to transmit for 1,500 kilometers the entire capacity of the power giant of the future -- the Nizhne-Lenskaya GES and this is after all no more and no less than 20,000,000 kilowatts, or 30 Dneprogeses. Poles the height of a 20-story house, garlands of insulators about 10 meters in length, 4-6 conductors in phase -- each the thickness of an arm, the right of way for the transmission line more than 100 meters wide -- approximately so will this line appear. Even if our descendants will not be oppressed by the dimensions of these structures, from the economic point of view they will not always be advantageous, particularly in thickly settled and industralized zones, where the cost of land is very high. At the same time, the upper limit of capacity for one 3-phase cable will scarcely be able to exceed 1,000,000 kilowatts.

And it was here that the idea of cooling was engendered: the cable operates at the temperature of liquid helium (-269°centigrade). At such

low temperatures a number of metals and alloys lose their electrical resistance and pass into a superconductive state. During the first experiment it was possible to bring the current density in a niobium layer to 112,000 amperes per square centimeter, which is more than 1,000 times the current density in conventional overhead lines.

And more. The property of superconductors make the quest for increasing voltage senseless. There is an actual possibility of effecting the transmission of power at the generator voltage, excluding from the series circuit such elements as step-up and step-down high-voltage transformers.

The efficiency of a superconductive electrical transmission line is considerably higher than in a conventional one. It falls short of 100 percent by only 1-2 percent, due to the fact that a relatively small amount of power is used for driving the refrigerators and supplying power to the rest of the auxiliary equipment.

It should not be thought, however, that the technical realization of the construction of a super conductive electrical transmission line is a simple matter. A multitude of problems still faces scientists and engineers. These problems include selection of the optimum value of the voltage and the optimum current type, and improvement of the thermal and electrical insulation, the finding of optimum pumping regimes for the cooling agent, leading the current into the low-temperature zone, protection from overloads and short circuits, methods of putting up and joining individual sections of cable — in a word, the work has scarcely been started. And nevertheless, the electric transmission line of the future is the superconducting cable.

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SUPERCONDUCTING POWER TRANSMISSION STUDIED

[Article: "Transmission"; Moscow, NTO, Russian, No 2, 1970, pp 12-13]

As is known, the phenomenon of superconductivity arises in certain metals, alloys, and chemical compounds when temperatures approach absolute zero and there is almost no electrical resistance. The tempting idea of utilizing this superconductivity for transmitting large amounts of electric power for considerable distances automatically comes to mind. If expenditures for operation of the cooling installation are not considered, the current would go through the superconducting cores of the cable without loss.

Power is now transmitted from the power station to the consumer mainly along high-voltage serial electrical transmission lines (LEP). Losses here depend on distance and frequently amount to 10-12 percent. In other words, by replacing ordinary LEP with superconducting main transmission line cable, the beneficial use of the electric power produced would probably increase by billions and billions of kilowatt hours on a nationwide scale.

There are also other very attractive ideas on the utilization of superconductivity in power engineering. The voltage at the busbars of generators at electrical stations is most often 10-20 kilowatts. At step-up transformer substations it is increased tenfold -- the greater the voltage the less the loss in LEP. However, as a rule, the customer requires low voltage. It is therefore necessary to install step-down substations. All this, of course, complicates and increases the cost of power transmission. Superconducting lines, however, could transmit electric power at generator voltages, thus avoiding substations. In addition, laying such a line would not requi·· so much space as aerial LEP.

In general, quite a few arguments can be given in favor of this idea. However, what is the situation with respect to putting it into practice?

A number of scientific and engineering problems must be solved before superconducting electric transmission lines can be constructed.

Above all, a cable is needed in which superconductivity would arise when it is chilled to a few degrees above absolute zero. Attaining low temperatures requires special refrigerating installations using liquid helium. Thermal insulation of the refrigerated cores demands consideration. Excessive heat flow to these cores from the outside would cause dangerous overheating. Superconductivity would be lost and electrical resistance would rise. It is also necessary to find a method of connecting generator busbars and customer lead-ins, at normal temperatures, to the refrigerated cable cores.

Does our present technology permit us to solve these problems? Yes without a doubt.

Let us begin with the superconducting cable. There is a design which was given a patent in the USSR in 1936. The core consists of aluminum tubes, on the surface of which are wrapped layers of fiberglass and a metalized alloy of lead-bismuth (it becomes a superconductor in liquid helium), which are insulated from one another. Three such cores are wrapped together and covered with a common coating. They are refrigerated by passing through them liquid helium which is returned to a refrigerating installation by being passed through the space between the outer surface of the core and the inner surface of the cable covering.

Thermal insulation is carried out by several methods simultaneously. First, air is evacuated from the cable's wrapping, for, as is known, a vacuum is ideal thermal insulation "material." Second, aluminum foil is wrapped around the core. This prevents heat radiation.

However, even with such measures, heat conduction would be quite extensive in thin cores. It is after all proportional to the fourth power of the difference in temperature and it is about 300 Kelvin degrees. In order to even further reduce heat conduction, the cable being refrigerated by liquid helium should be enclosed in a covering around which liquid nitrogen or air should pass. This would reduce heat conduction in the cores by a factor of about 100.

How can heat penetration into the cable through current-carrying leads be reduced to a minimum? For this purpose, especially designed terminals are suggested to which the cable would be connected to the generator at the station and to the distribution installations at the user. Glass is a very suitable material for this purpose. It is a poor heat conductor, and when mixed with certain alloys it does a good job in maintaining a vacuum. Experimental models of terminals have been partially tested in the low-temperature laboratory of the All-Union Electrotechnical Institute and have given satisfactory results.

The installations supplying liquid nitrogen and helium for the outer part of the cable should be highly reliable. Superconductivity is subject to dangers other than heating beyond critical temperatures. It can also

cables which do not lose electricity is a task encompassing extensive prospects for the development of electricity into the USSR."

Similar developments are now taking place in other countries. For instance, in 1968 the journal Energokhozyaystvo za Rubezhom reported an American plan for a superconducting line to transmit energy 100 kilometers. It should transmit 500 kiloamperes D.C. at a voltage of 200 kilovolts, in other words, have a capacity of ten million kilowatts. An alloy of niobium and tin ($Nb_3 Sn$) was selected as the superconductor. The conducting cross section of the cable is 600 square millimeters. Such a line is supposed to be installed in a vacuum-tight metal channel enclosed in a concrete conduit, which can be both at ground level or under it. A refrigerating installation liquifying nitrogen or helium will be situated every 20 kilometers along the line. The liquification of these cooling agents and the operation of vacuum pumps are basic operational expenditures. They will cost about five million dollars annually, which is many times less than for aerial LEP of the same capacity.

The method of industrial liquification of helium suggested by the authors of the article will permit attaining an even greater effect. This will considerable reduce capital expenditures on the installation of superconducting lines independently of whether A.C. or D.C. is being conducted.

It appears that it will not be long until superconducting cable lines are more than just plans. Soviet power engineers can and should be pioneers in this field. Scientific and technical societies, primarily members of the scientific and technical societies of the power engineering industry, can do a lot to accelerate practical realization of the possibility of transmitting current without loss.

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MARCH OF THE PYLONS NEARS ITS END

Soviet Weekly, June 3, 1972 p.10

IN THE Power Engineering Institute in Moscow is a prototype of an electric power transmission system which forecasts the end of great lines of pylons carrying overhead wires across the countryside.

It may seem odd to be saying that the end of the pylon is in sight when other engineers are planning to build ever more powerful overhead lines in the next twenty years.

The very increase in capacity planned, however, will bring power engineers to the limits possible with this type of transmission.

Already the Soviet Union has overhead lines operating at 750 kilovolts, and plans are in hand for lines of 1500 kV.

But that will be the swan song of the pylon, because the insulating capacity of the atmosphere can take no more.

The next generation of power systems will need to use another technology.

The two possible alternatives in sight at the moment are high frequency waveguides or superconductors operating at very low temperatures.

It is the latter which forms the basis of the test installation at the Power Engineering Institute.

On several floors of the institute is an assembly of pipes and tanks which serve a four-metre metal pipe which holds the superconductor and the liquid helium and keeps it at a temperature only four degrees above absolute zero – and it works.

One of the project engineers described some of the problems it has taken them years to solve.

The first of these, said Evgeny Goldenberg, was to find a superconductor with the right properties for the expected operating conditions.

The final choice after a long search was a film of tin-niobium alloy.

Then it was necessary to hold the temperature at only four degrees above absolute zero without incurring unacceptable losses of the coolant liquid helium.

This was done by enclosing the superconducting film in a series of jackets of liquid helium and vacuum pipes which keep the film at −269°C, while the outside of the assembly is at room temperature.

The installation is very similar to the final form expected for underground superconducting cables of the future.

The potential limit of superconductive cables is somewhere in the region of 100 million kilowatts.

To improve the reliability characteristics, the superconductive film is laid on the surface of a copper band.

In the event of a breakdown it should temporarily make up for the break.

The experts' conception of a regular superconductive power transmission line is an underground cable several hundred miles long.

Cryogenic plants will be arranged at uniform intervals along the line, to maintain uniformly low temperatures in the sections.

This line will be controlled from a single station.

Such lines will not only eliminate power losses in transmission of electricity over vast distances.

In the long run they will replace all overhead power transmission lines.

ELECTRIC POWER AND RELATED EQUIPMENT

FUTURE PROSPECTS IN POWER ENGINEERING DISCUSSED

[Interview with D. V. Razevig, doctor of technical sciences and director of the State Scientific Research Institute of Power Engineering imeni G. M. Krzhizhanovskiy, by Novosti Press Agency; Moscow, Gudok, Russian, 6 April 1973, p 4]

The scientists of the State Scientific Research Institute of Power Engineering are now trying to solve problems that will affect the future of power engineering. One of the directions in which they are searching -- the development of new methods of transmitting electricity over large distances -- is the subject of this interview.

Question: Scientists and power engineers in many countries are intensifying their work on cable power transmission lines (LEP). Does this mean that they are not satisfied with overhead LEP's?

Answer: For the time being they are satisfied, but in the next few decades the possibilities of overhead LEP's will probably be exhausted. Therefore, we are already studying various alternatives for replacing them.

There are three alternatives that appear to be very promising for the near future. One of these is gas-insulated lines, which are metal pipes filled with a compressed gas. Pipes 200-300 mm in diameter are adequate to carry 220-330,000 volts, although by increasing the gas pressure in the pipe we can double or triple the voltage.

The second type of cable that has been proposed is the so-called cryoresistive type. It is based on the reduction of resistance to an electrical flow in chemically pure metals when they are cooled to extremely low temperatures. Electricity losses in these cables would be quite low. I think that they will appear by 1977, at the latest.

The third alternative is superconductive cables. The first LEP using this type of cable will be built in 1975-1976. The special features of these LEP's is that they operate at temperatures close to absolute zero (-273°C). The current-carrying core of these LEP's is made of special superconductive materials -- niobium or niobium alloys. Right now, the losses suffered during transmission constitute almost 10 percent of the total amount of generated electricity. In the new alternating current lines, the losses will be reduced to a minimum. The transmissive capacity of these LEP's will be so great that it is hard to see how they will be needed before the end of the century. All of the cables about which I have been talking will, of course, be laid underground.

In the future, we will be able to talk about building entire superconductive electrical systems. This means that all the elements in them -- generators, transformers, lines, and even the transformers used to convert alternating into direct current -- will be superconductive. What is more, we have theoretically proven the possibility of building superconductive electricity accumulators.

Question: Do you mean devices of the storage battery type?

Answer: Not only that. Right now, power engineers are faced with a pressing problem -- how to cover peak load periods. The present solution is to build additional electric power stations that operate at the peak hours only; that is, for a few hours a day.

You have probably heard of derivational electric power stations. Water flowing from rivers or reservoirs at a higher elevation than the station turns their turbines. Such stations have only one function -- that of generating power.

Right now we are building so-called pumped-storage electric power stations. The principle on which they operate consists of using their turbines in two roles, as both generators and pumps. Basically, the turbines function as pumps, by pumping water from a river upward, into special reservoirs, from which it flows down through the turbines when extra power is needed (at the peak load periods), at which time they function as generators. One of these stations is already in operation, near Kiev, and construction will soon begin on another at Zagorsk, near Moscow.

However, our scientists are also studying other methods of storing electricity. One of these can be a superconductive winding with high inductance. During "slack" periods, electricity is "pumped" into the winding and stored.

Question: Thermal electric power stations pollute the atmosphere. Can this be avoided?

Answer: It all depends on the fuel. Gas causes less pollution than other fuels. Many harmful byproducts -- especially sulphur -- are generated when oil and fuel oil are used. However, this emphatically does not mean that thermal electric power stations will also pollute the atmosphere in the future. Our institute's specialists are working on methods of cleaning up coal, fuel oil, and oil shale. This will help in achieving two goals: purifying the atmosphere and supplying the chemical industry with valuable raw material.

However, we are placing our greatest hopes on the purest of all fuels -- atomic fuel. This is the fuel of the future. Atomic electric power stations eliminate the transmission problem, because they can be located in industrial centers that do not have supplies of fuel nearby.

The next stage will be thermonuclear electric power stations. It is hard to say exactly when the first one will be built, but we power engineers must begin preparing for them. We have to find methods of integrating these titanic power sources into the power systems that are already in operation. There will undoubtedly be great difficulties to be overcome in this area. Thermonuclear electric power stations actually promise to deliver at least 10 times the power of those stations we now have. We also have to solve the problem of how to distribute the power generated by them to consumers that are some distance from the station.

Question: We can assume that thermonuclear electric power stations will generate a great deal of heat. If it is dissipated in reservoirs and rivers, will it not destroy the ecological balance?

Answer: If these electric power stations are based on the use of thermal energy, this problem is certain to appear. However, another arrangement is possible, where the energy of the thermonuclear synthesis is converted directly into electricity, bypassing the thermal stage.

Question: We have recently heard much talk about magnetohydrodynamic generators as a source of cheap electricity. Are the workers in your institute also involved with them?

Answer: Not only we, but many other scientific establishments are working on the creation of magnetohydrodynamic generators. A gas-powered model has already been built. Our present goal is to redesign those units that operate on solid

fuels. Once again, however, we must face the problem of preventing atmospheric pollution.

The future of power engineering -- and about this we have no doubts whatsoever -- is related to ultrahigh temperatures and the use of plasma-powered installations. However, plasma is a very new material in this respect, and we must first learn how to control it.

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

APPENDIX 5b

Subjects of Possible New Cooperation in Energy Research and Development Suggestions by the US and USSR Delegations

Extraction of Oil from Oil-bearing Formations

As oil deposits in the large, older producing regions are being depleted, the USSR is trying to initiate secondary and tertiary recovery methods to increase the yield of oil from such deposits. The Soviets claim that their over-all recovery of oil from producing oil fields in the country averages 43% to 44%. This would be a high yield, as the US rate is only about 33%. However, the USSR uses water flooding as a standard procedure in the early stages of development of most of its oil fields to a much greater extent than does the US. This pressure maintenance method, if conducted properly, should increase eventual oil recovery. Nevertheless, the Soviets have made serious mistakes in waterflooding in at least one major field -- the Romashkino field in the Urals-Volga region -- that sharply reduced the potential oil yield.

During the latter part of November 1974, Soviet oil officials expressed interest in signing agreements with two US oil firms (Standard Oil of Indiana and Union Oil) to conduct work for increasing oil recovery from existing fields. At that time they claimed oil yields from their fields ranged from 10% to 50%. Soviet plans for the future place a high priority on increasing oil yields from existing fields. They are investigating and using, where possible,

most of the secondary and tertiary recovery methods available in the West -- water injection with surfactants or polymers, and carbon dioxide injection, gas injection, steam injection, fire flood. Most of these methods are recognized as having potential but they have not contributed any significant increases in oil production to date. In 1973 it was reported by the Ministry of Petroleum that secondary and tertiary recovery methods yielded only about 1.3 million tons of oil out of a total national output of some 421 million tons.

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Improving the Efficiency of Geophysical Exploration

In recent years Soviet oil officials have complained about the industry's failure to discover oil reserves necessary to keep pace with planned increases in production. Much of the blame is attributed to poor geophysical work and a lack of coordination between geologists and exploratory drilling teams. As prospecting is conducted in permafrost areas of Siberia and deeper formations in older producing regions, Soviet technicians are confronted with more complex geophysical conditions. Much of Soviet geophysical equipment is 10 to 15 years behind that in the US and cannot provide the data needed to evaluate potential oil and gas formations. As a result a larger number of exploration wells are being drilled without success in locating petroleum deposits.

Recent articles by high-level oil officials urgently call for improvements in seismic exploration work, adoption of the latest developments in exploration geophysics, and greater control over geological exploration work to improve the effectiveness of petroleum exploration in the USSR. Only during the past few years, however, has the USSR adopted some of the more sophisticated methods that have been used in the West for at least 10-12 years. For example, the rapid advance in computer analysis of seismic records has revolutionized western oil and gas exploration since 1963, but the

Soviets are still making the transition from analog to digital field recording units, and the development of computer playback centers is in its early stages in the USSR. [redacted] STAT

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Soviet seismic equipment was obsolescent and inadequate for the exploratory work necessary to locate new gas reserves for the proposed cooperative liquefied natural gas (LNG) venture. Thus, if the USSR is to be successful in maintaining self-sufficiency in petroleum production for the foreseeable future, significant improvements in exploration are a necessity.

Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

Techniques and Technology of Well Drilling (including high pressure and high temperature conditions)

In the USSR the turbodrill is used for about three-fourths of all drilling. Turbodrilling was adopted primarily because lower quality drill pipe could be used as the down-hole turbine places little or no torque on the drill pipe. The turbodrill is ideally suited for shallow, hard rock formations but loses efficiency at depths below 8,000 feet. The turbodrill has proved to be efficient in drilling of slant holes, especially in areas of West Siberia where several wells are drilled from clusters or artificial islands. Some recent improvements have been made in the turbodrill -- a hydrodynamic brake to develop high torque at low rpm's and ball bearings instead of rubber bearings -- to permit its use at depths up to 10,000 feet and at higher temperatures.

Although rotary drilling accounts for less than one-fourth of total drilling in the USSR and little research is underway to improve it, the Soviets recognize certain of its advantages. Soviet drillers use rotary drills for most deep wells, especially those encountering high temperatures and pressures. They also employ rotary drilling for wells encountering shales or other types of rock that require heavy bit weight.

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

Anti-Corrosive Protection of Technological Equipment and Pipelines

Soviet articles in technical journals have indicated the need for control of internal and external corrosion of gas pipelines and other underground structures. Research is underway on new coatings to protect operating gas pipelines. A recent article1/ states that an anti-rust polymer coating made from cheap industrial by-products has been developed and tested. The Soviets claim that it gives better protection than more conventional coatings, such as expoxy resins which cost 80 times more.

1/ Soviet Weekly, 7 December 1974, p. 3.

[redacted] 25X1

Liquefaction and Cooling of Natural Gas

The USSR has no facilities for liquefaction of natural gas on a commercial scale. The proposed cooperative ventures with US and Japanese firms to liquefy natural gas and export it would represent the first Soviet efforts in the LNG business. The Soviets have no known plans to initiate an LNG operation for domestic use. A Soviet technician, O. Ivantsov, has authored several papers on the development of an LNG pipeline system in the USSR but no work has been done on this project. Western experts have criticized Ivantsov's papers for his lack of understanding of the technology involved.

The USSR, however, does have 2 plants for the recovery of helium from natural gas by low temperature liquefaction. They are the only known commercial-scale cryogenic facilities processing natural gas in the Soviet Union.

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Drilling of Gas and Gas-Condensate Wells in Permafrost Areas and in Ocean Ice Conditions

Soviet drilling and producing operations in the permafrost regions of Siberia have been improving after several years of trial and error. When the Soviets began operations in the north, where temperatures are as low as -50°C, they brought standard rigs and transport equipment designed for temperate climates. Frequent equipment failures resulted from metal brittleness. After experiencing several drilling disasters, including one where a large part of the reserves of an entire gas field was lost because the well casing collapsed when the permafrost melted, Soviet technicians have succeeded in overcoming many of the major problems. They are striving to deal with the main problems of freezing and thawing and hydrate formation in drilling and producing gas wells in the northern regions. They attempt to keep the permafrost zone around the well casing frozen and use cooled brine drilling fluids to prevent ground thaw. No oil-base muds are used yet but research is underway to develop them. Hydrates tend to form in permafrost gas wells but the Soviets inject methanol continuously to minimize such formation.

The Soviets have by no means solved all of the problems inherent in permafrost drilling operations. Some subsidence occurs around the well heads and casing, particularly during

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shut-in periods after wells have been produced. The make-up and handling of drilling fluids in permafrost conditions are far inferior to Western practice. No special precautions are taken to prevent gas from forming hydrates as a result of heat formed as well casing cement hardens.

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Soviet Oil and Gas Industry Research Institutes

Geology

VNIGNI (All Union Scientific Research Institute for Geological Prospecting), Moscow

Oil Production

VNIIBT (All Union Scientific Research Institute for Drilling Technology), Moscow

Azerbaydzhan Scientific Research Institute for Petroleum Production, Baku

Groznyy Petroleum Institute, Groznyy

Ufa Petroleum Institute, Ufa

Refining and Petrochemicals

VNIIPINeft (All Union Scientific Research and Planning Institute of the Petroleum Refining and Petrochemical Industry), Moscow

Giproneftespetsmontazh (State Institute for Planning of the Technical Assembly of Enterprises of the Petroleum Refining and Petrochemical Industry), Moscow

Machine Building

VNII Neftemash (All Union Scientific Research, Planning and Design Institute for Petroleum Equipment), Moscow

Azerbaydzhan Scientific Research Institute of Petroleum Machine Building, Baku

Gas

All Union Scientific Research Institute for the Gas Industry, Moscow

Pipelines

All Union Scientific Research Institute for Construction of Main Pipelines

Hydraulic Production of Coal

The USSR has been experimenting with hydraulic mining techniques since the 1930s and currently produces about 10 million tons of coal per year by this method. Large pressure pumps on the surface pump water by pipeline down into the mine, where it is directed by a nozzle, or monitor, against the coal face. The coal broken from the face by the pressure of the water is then washed along the mine floor where it is collected, crushed, re-mixed with water, and pumped to the surface.

The USSR claims substantial reductions in cost through the use of hydraulic techniques. However, a US delegation that visited the USSR in 1970 reported that Soviet authorities had decided in 1967 not to build any more hydraulic mines until some of the technical problems had been solved, including excessive losses of coal as a result of premature caving, large expenditures of energy per ton of coal extracted, and high temperatures and humidity associated with hydraulic mining.

Some aspects of Soviet technology in this field may be of commercial interest to the US as Kaiser Resources Ltd. of Canada recently reported the conclusion of an agreement with the USSR, and with Mitsui Mining Company of Japan, to market internationally Soviet, Japanese and Canadian

hydraulic coal-mining technology. Part of Kaiser Resources British Columbia coal mining operation utilizes a hydraulic mining method developed by Mitsui Mining.

Most of the research and development work in the USSR on hydraulic mining is carried out by All-union Hudraulic Mining Institute in Novo Kuznetsk (Kuznet Coal Basin) and the Ukrainian Hydraulic Mining Institute in Lugansk (Donets Coal Basin). A partial list of mines employing hydraulic techniques is attached.

The USSR also uses hydraulic monitors, to a limited extent, to remove overburden in equipment coal mining operations. One installation which employs this technique is the Kedrovskiy mine in the Kuznets Basin.

Soviet Mines Employ Hydraulic Techniques

Kuznets Basin:

Polysayevskaya-Severnaya

Krasnogorskaya

Baydayevskaya-Severnaya No. 1 & No. 2

Gramoteinskaya No. 3/4

Koksovaya No. 1

Ziminka No. 3/4

Tomusinskaya No. 1-2

Kiselevskaya

Dzhubileynaya

Donets Basin:

Yanovskiy

Odesskaya No. 2

Pioner

Karagandn Basin:

Saranskaya No. 106

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V.R. Sa'nikov, Experience and Outlook for Utilization of Hydro-Mechanization at Steeply-Pitching Coal Seams in the Kuznets Basin, Ugol' (Coal), No. 7, Moscow, 1973, pp. 9-11.

N.V. Melnikov, Mineral'noye Toplivo (Mineral Fuels), Moscow 1971, pp. 127-129.

Report of the United States Coal Mining Delegation to the USSR, 30 May - 16 June 1970, p. 12.

THE FUTURE DEVELOPMENTS IN HYDRAULIC COAL MINING

[Following is the translation of an article by N. N. Ignatov in Ugol' (Coal), No 10, Moscow, 1961, pp 15-19.]

The proposed program of the CPSU stipulates that a higher industrial labor productivity is one of the most important tasks in the building of a material and technological basis of Communism. One way to achieve that in the coal industry is to introduce the mining techniques not requiring constant attendance in the stopes.

The introduction and expansion of hydraulic mining will set up a continuous and simple operation, at the same time raising the labor productivity and improving the working conditions.

This technique was introduced on an industry-wide scale, in the Donets and Kuznetsk basins, following the XXI Congress of the CPSU. In 1959, 1,020,000 tons of coal was mined hydraulically, in the USSR; in 1960, 1,870,000 tons --as against 250,000 tons in 1956. Hydraulic shafts and sectors with a capacity of over 2.5 million tons were put into production in 1959-1960.

Table 1

Mines	1960 hydraulic method	1960 conventional method	Maximum hydraulic production attained
"Odessa-Komsomol" (Donbas)	56.6	40.0	88.5
"Polysayevsk-North" (Kuzbas)	78.0	61.4	108.6
No 3-4 "Ziminka" (Kuzbas)	80.0	54.6	125.0
"Tomusinsk 1-2" (Kuzbas)	81.0	49.8	105.0

Experience of the first two years has shown high production indexes obtained after the introduction of hydraulic mining: the production cost was 20-40% lower than for the conventional method, and the expenditure of bracing timber was 300% lower.

The actual labor productivity in hydraulic mines is given in Table 1 (tons/month). These figures were obtained with inadequate equipment, in small mines and sectors, mostly underfulfilling their quotas. The use of new equipment, now in production, and the introduction of automation, will improve the mine performance and achieve a calculated

labor productivity several times higher than in conventionally worked mines. The labor productivity and production cost for large hydraulic mines and sectors, now under construction, are given in Table 2 (planned data).

Table 2

Basins	Production per man, tons/month	Cost production of one ton of coal, in rubles (including benefication)
Kuznetsk	137-214	3.2-4.1
Donets	78-129	4.8-7.2
Karaganda	109	4.0-4.3

A considerable development of hydraulic mining is contemplated even in the current Seven-Year Plan. However, the main 1961-1965 task is to organize the production of high-powered and reliable equipment and to introduce the new techniques under various geologic and mining conditions. All that will promote a more rapid development of hydraulic mining, in the coming years.

The relative volume of hydraulically mined coal is tentatively estimated at 21-22% of the total USSR underground coal production, with the Kuznetsk basin affording the possibility of mining about half of its coal, hydraulically. To achieve this goal, the annual production rise for the hydraulically mined coal must exceed by at least 150-200% that contemplated for the current Seven-Year Plan.

As shown by the experience of recent years, underground hydraulic mining is most effective under certain conditions. Its main application is in the mining of coking coals subject to wet benefication.

Hydraulic mining of power-generating coals will be developed depending on the use to be found for small size coal, at electrostations, with the coal transported hydraulically from the mine to the consumer.

The development of hydraulic coal mining is planned to be achieved by building new mines as well as by converting to this method those mines where the geologic and other factors warrant it.

As shown by planning calculations, the hydraulic method is most effective in large shafts combined into mines with a central economy and a central benefication plant. Such mines are now under construction, as witness the Yanovsk hydraulic mine in theDonbas, with a total capacity of 3 million tons; the Raspad mine in the Kuzbas, 4.8 million tons; the Bystryanka in Rostovskaya Oblast, 3.4 million tons, and a number of others.

The construction of individual hydraulic segments in active Donbas and Kuzbas mines has been a positive factor in gaining experience with hydraulic production under various geologic and mining conditions

and in building up a trained personnel. However, this practice of small scale hydraulic mining should be abandoned because it does not solve the problem of raising the coal production indexes.

Hence the future trend will be to build new hydraulic shafts and to reconstruct and convert to this method large shafts and the entire coal districts. Thus the plan estimates show that a conversion to open and hydraulic mining of the Tom-Usinskiy Rayon (Kuzbas) will achieve the rayon-wide labor productivity of 15.6 tons per man per shift, with the corresponding figure of 12.8 tons for hydraulic mining.

It is planned to mine the coal mainly without tracing, in unattended stopes. Considering the geologic and mining conditions of new and converted shafts, the anticipated production is as follows:

a) about 30% of coal to be mined with high-pressure hydromonitor jets, impulse jets, and high-pressure thin jets, remotely or automatically controlled;

b) about 30% with a preliminary weakening of the coal body by pumping in water or by blasting in long boreholes;

c) about 40% by automatic hydraulic mining machines, with an automatic or remote control.

As shown by experience and calculations, the last method is the most efficient, under appropriate conditions. A diagram of its working is presented in Figure 1.

Depending on the extent of the plan fulfillment by this method of mining, the anticipated labor productivity for hydraulic mines of the Soviet Union as a whole will be 140-150 tons per man, per month.

In these mines, the coal will be transported mostly by gravity flow. Pressure flow is planned for very gently dipping horizons, in large mines; in converted shafts it is to be used in mining of normally dipping horizons.

It is planned to lift the coal with powerful pumps, by chamber and helice feeders, and by air lift.

As a rule, it is planned to transport the coal to the central benefication plant or directly to the consumer, through high pressure pipelines, with special surface booster stations.

The design organizations are now busy with plans for auxiliary transportation in mines and with designs for engines for mono- and conventional rail transportation of men and material in main galleries. Hydraulic drive monorail locomotives (hydrotelphers) have already been designed; a number of organizations are working on diesel tractors for hydraulic mines.

It is planned to do the mining mostly with hydromechanical machinery. Hydromechanical coal miners PKG-4 and LMGP are already in production; industrial testing is being done for combination of models, to mine hard coal in soft rock.

Benefication and dehydration of coal is of great importance in hydraulic mining. A paramount role will belong to non-classified settling of coal in high-capacity settling machines. Flotation of sludge is also contemplated in benefication of coking coals.

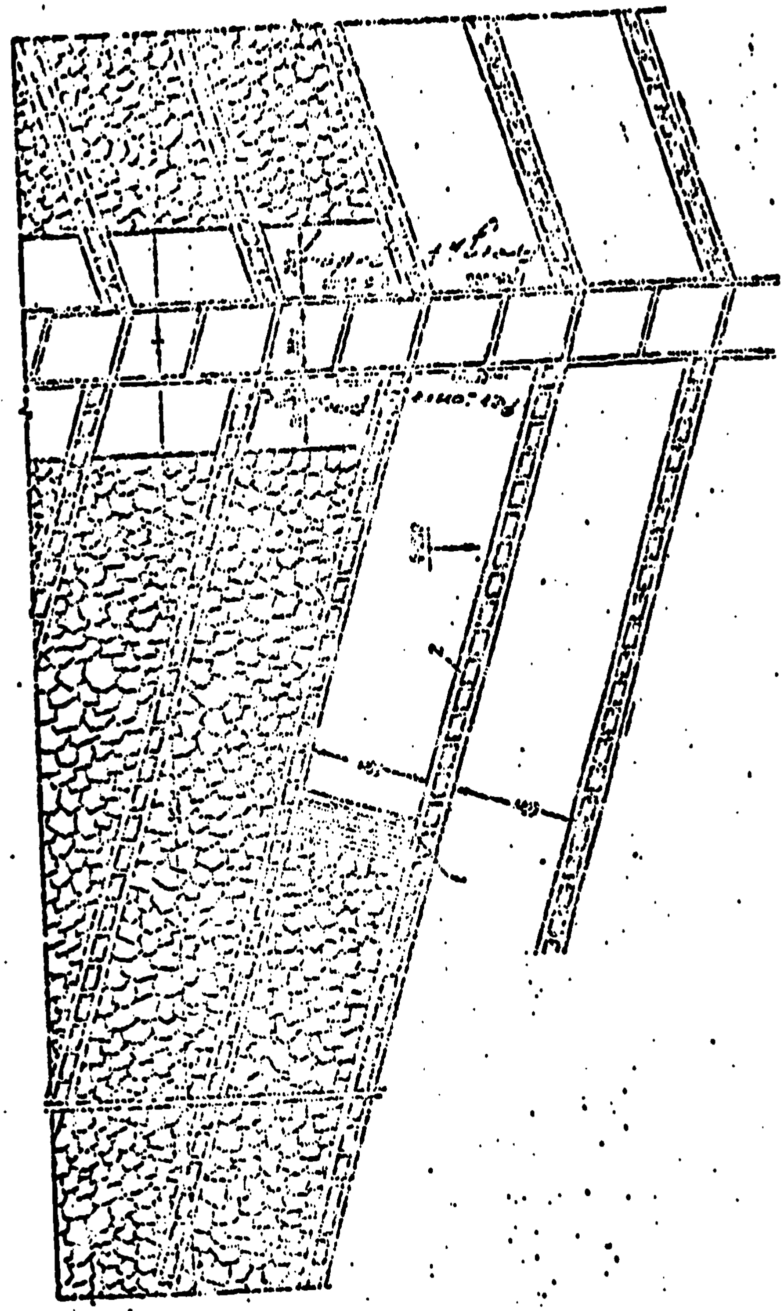

Fig. 1. Diagram of hydromechanical coal mining.
1) hydromechanical cutting machine;
2) gathering drift.

The dehydrating of coal will be done by screening and by centrifugal filtering and settling. Production is underway for horizontal (UTsM-1, UTsM-2, and UTsM-3) and vertical centrifugals (NVV-1000) which will be fully adequate for the needs of hydraulic mines.

Of particular importance is the clarification of water returned to hydraulic mines, because the degree of clarification affects the performance and life of hydraulic equipment. Recent experience has shown that a coagulant of the polyacryl-amide type in an effective and reliable clarifying agent. The necessary equipment is being mass-produced by our industry.

The moisture control in small size coal will be done in thermal dryers, in the mines.

The continuous nature and simplicity of hydraulic coal mining lends itself to thorough automation. Accordingly, it is planned to automate all hydraulic mines, thus attaining an even higher labor productivity.

These main trends in hydraulic mining do not exhaust all its possibilities. In a number of instances, hydraulic transportation may be effectively combined with the conventional mining; certain individual tasks can be converted to hydraulic, such as coal lift, gangue rock disposal to worked-out sections, etc.

In recent years our industry has started mass production of equipment allowing hydromechanization of mines. In many instances, this equipment is inadequate and short-lived. Although the actual engineering and economic indexes for hydraulic shafts are higher than for the conventional ones, the shortcomings of the present equipment prevent, in most instances, the achievement of planned goals.

For this reason, the construction and introduction of new high-powered, reliable and durable equipment remains an urgent task: without such equipment, a high production rate cannot be achieved.

In recent years, a number of design and research organizations have been called upon in the developing of hydraulic mining equipment. The number of designers engaged in this work has grown several times, as compared with 1959. Still the progress in design and testing is too slow and the volume of work is too low for a rapid development of coal mining. We shall pause for a few problems which we believe to be critical in this field.

The equipment on hand is adequate for satisfactory results in the mining of soft and fractured coals. Accordingly, a preliminary loosening of hard coals by explosives is practiced in hydraulic mines. With the present methods of drilling and explosion, this leads to a considerable deterioration of performance indexes. All effort should be bent toward a prompt devising of more effective mining methods.

There are now two trends in this field; both of them should be pursued simultaneously. The introduction of high-pressure (over 100 atm) jets, impulse jets, and high-pressure thin jets will broaden the field of application of hydraulic mining. Work in this field is being done at several institutes. It should be kept in mind, however, that there are problems of safety in operating with high pressures, also of automatic

and programmed control of hydromonitors with return communications, etc. A prompt solution of these problems is imperative.

As shown by calculations, the mining of intermediate to hard coals is best done with self-propelling hydromechanical machines which combine the disintegration of a coal body by mechanical elements driven by a hydraulic turbine, and the removal of coal by the worked-out water.

The first such machine -- combine GK designed by Ya. Gumennik, the recipient of the Lenin Prize -- passed the test in the Dzerzhinskiy No 12 mine (Donbas). The experimental mining speed was 60-75 m/hr, with a full automatic control, serviced by two men. The mining was done without bracing and with the stope unattended.

This operation is diagrammed in Fig. 2.

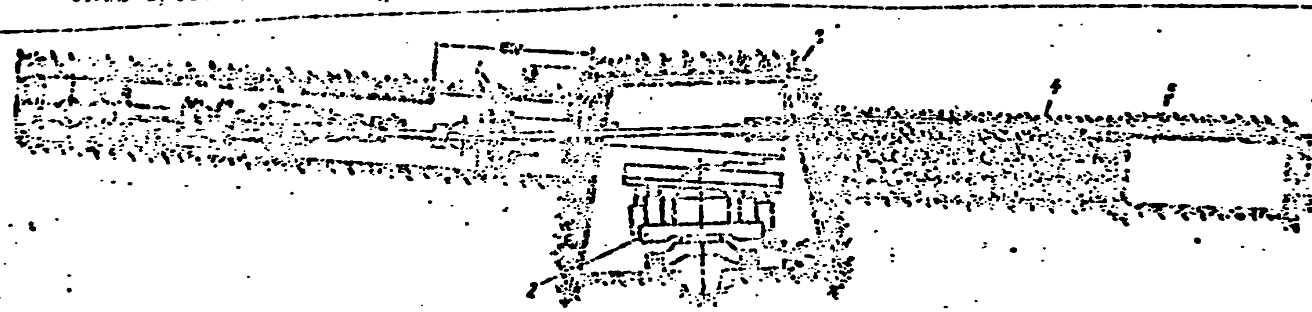

Fig. 2. The working of hydromechanical miner KG
1) position of the combine on its guiding carriage, before the start;
2) guiding carriage; 3) gathering drift; 4) cross-stay; 5) cross-cut.

Experimental results show that for coal beds about one meter thick, it is possible to produce over 100 tons of coal per man, per shift, i.e. many times more than in the best stopes, conventionally mined. Moreover, there practically is no labor-consuming cutting and there is additional saving on bracing timber.

The use of such hydromechanical miners opens up vast possibilities for hydromechanization

of shafts in coals of any harness, unattended and safe. Accordingly, it is essential to speed up and expand the production and introduction of such machines, adapted to different geologic and mining conditions -- first of all to hydraulic mining of thin beds whose future importance will be great.

The designing of effective means and methods of a preliminary weakening of the coal body, too, should be continued. For instance, studies by the A. A. Skoninskiy Mining Institute, in cooperation with mine workers, show that a weakening of hard coals by pumped-in water raises the productivity of hydromonitors and lowers by about 30% the labor consumption. Quite effective economically also is the weakening of the coal body by blasting in long holes with hydraulic tamping.

The second most critical task is the designing of effective means of hydraulic lifting the coal from great depths (600-300 meters) in hydraulic mining. A prompt solution of this problem is particularly important in connection with the building of deep hydraulic mines in the Donbas, during the current Seven-Year Plan.

Experimental models of high-pressure coal pumps (16 - UBT) have been constructed recently; chamber-and helice leading devices for hydraulic lifting of coal are being tested; and preparations are underway for testing an experimental air-lift installation in the Donbas. However, all these operations are obviously too slow, and should be speeded up. At the same time, it is necessary to expand research in the improvement of technology and in eliminating the shortcomings. We believe that the main effort should be directed to the following tasks:

a) to improve the hydraulic mining methods so as to reduce the amount of preliminary cutting and the coal losses -- the two large items under the present conditions, affecting the mining economy;

b) to reduce the fractioning of coals in hydraulic mining and transportation. This is even more conspicuous in the presently operating hydraulic mines, where it hampers the dehydration of coal and raises the cost of benefication;

c) to raise the wear resistance and to lengthen the life of hydraulic equipment;

d) to intensify and expand research in the field of coal disintegration by hydromonitor jets and to establish the optimum hydraulic mining parameters;

It is also necessary to intensify the planning work and to improve the construction of hydraulic shafts. The lag in this construction, in the Donbas and Kuzbas, slows down the progress of hydraulic mining, during the current Seven-Year Plan. Measures should be taken to overcome this lag.

The broad introduction of hydraulic mining in coal mines is quite important, economically and socially. It constitutes a realistic means of fulfilling the industrial goals set up by our Party, in achieving a higher labor productivity, a radical improvement in working conditions for the miners, and in building the material and technological basis of communism.

Underground Coal Gasification

The USSR has been experimenting with the underground gasification of coal for many years. At present, it has several small gasification units in operation, the largest of which is located at Angren in Uzbek SSR. Others are located in Tula and South-Abinsk. Installations built in Moscow, Lisichansk, and Kanensk may no longer be in operation. The product has a heat value of only about 90 BTU's per cubic foot, one-tenth that of natural gas. Underground gasification of coal is considered by US experts to be technically feasible, but its economic viability is as yet uncertain.

The Soviets claim significant advances in this field and US observers report the Soviet technology, in some respects, is superior to US technology. For example, the Soviets are said to ahve developed pneumatic technology not presently available in the US for breaking up the coal prior to its ignition.

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

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RS Sept 67
USSR Ind. Develop,
Elec Power, Fuels, etc No 72

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CONTINUED OPERATION OF UNDERGROUND COAL GASIFICATION STATION DEFENDED

[Following is a translation of an article by I. Mints, Candidate of Economic Sciences, and Ye. Rodimkin, Candidate of Technical Sciences, entitled "The National Economy Needs the Podzemgas* Station" in the Russian-language periodical Ekonomika i zhizn' (Economics and Life), No 6, Tashkent, 1967, pages 61-63.]

The problem of fashioning a scientifically sound fuel-power balance in the republic is an urgent one, for on its solution depends to a considerable degree a cutback in expenditures for fuel and power.

I would like, in this connection, to say something concerning the article by A. Irgashev and I. Ibragimov about the effectiveness of underground gasification of coal at the Angren Podzemgaz Station**. The authors of the essay proceed from the disputable (in our view) proposition that the "economic effectiveness of the 'Podzemgaz' Station's work -- and probably of every other one -- must be determined first of all by the degree of useful application of the fuel reserves going immediately to power needs."

It is appropriate to recall that in the modern state of development of deposits, fuel losses occur not only in underground gasification but also in the extraction of other forms of fuel. Specifically, working of the upper complex of the Angren deposit itself extracts only 38.5 percent of the coal, resulting in losses of 61.5 percent. The degree to which fuel reserves are utilized influences the economic indices of underground gasification -- specific capital investments and operating expenditures. However, these indices depend in significant

*Podzemnaya gasifikatsiya; underground gasification (of coal).
**"Underground Gasification. Is It Justifying Itself?" Ekonomika i zhizn', No 7, 1966.

measure on other factors, in particular — and this follows from the text of the article itself — on the expenditures of gas and electrical power for the station's own needs.

The composite index which most completely reflects production expenses is the cost of the gas obtained by underground gasification. And it should be borne in mind here that, with the existing system of accounting, it is in general impossible to determine precisely the genuine expenditures for the various forms of fuel, including gas from underground gasification, since the portion of the labor not reimbursed to society is not considered at present. If you look at it that way, then the sole index which can be applied in a comparative evaluation of the effectiveness of the use of gas from underground gasification of coal is not the degree of utilization of the fuel [coal] reserve in this process but the cost of the gas. As is well known, expenditures for electricity make up a very large portion of the cost. Therefore, a true assessment of the cost of the electricity used in underground gasification of Angren coal has great significance.

Electricity is being sold to the Podzemgaz stations at a price much lower than the cost of gas from underground gasification which is used to produce the electricity. It should also be emphasized that all the gas from underground gasification is used for generating electricity. By setting for the electricity a selling price which is lower than its actual cost, we in essence underestimate the cost of gas production, thrusting part of the costs of underground gasification onto power-grid operation. And it is impossible not to agree with the opinion of A. Igrashev and I. Ibragimov that the power expended on the production of gas by underground gasification should be priced at cost.

The amortization of principal funds are considered in this index. And since the capital investments from these funds have already been made, they will prove to be direct losses to the national economy if underground gasification is curtailed. Consequently, the share for amortization must be excluded from the cost of the gas from underground gasification.

The authors of the article cast doubt on the expediency of using gas from underground gasification because of the unprofitability of its production. High cost, it goes without saying, must attract the attention of specialists when the efficiency of the utilization of gas from underground gasification is being evaluated. However, in itself the unprofitability of an enterprise, selling prices being what they are, cannot be viewed as the chief criterion of low effectiveness of a given form of fuel. It is appropriate to recall that the whole coal industry of the USSR is unprofitable because of the poorly grounded selling price of coal.

It should be borne in mind further that in Uzbekistan, notwithstanding the large reserves of cheap natural gas, the fuel-power balance remains extremely precarious. In 1965 the deficit of solid fuel in Central Asia exceeded 2 million tons. This is why, in addition to using inexpensive natural gas, we are obliged to use comparatively costly forms of fuel, including Kirghiz and Tadzhik coal from mines.

Thus, if we curtail gasification or close the station, we will have to search for other forms of fuel which will demand not only annual expenditures for operation but also the original one-time capital investments for extraction. Meanwhile, large resources have been expended on the equipment of the underground gasification installations. Therefore, the cost of producing gas by underground gasification should be compared only with the capital investments and cost of that form of fuel which we shall substitute for it.

An analysis of the outlook for devising a fuel-power balance for the republic indicates that perhaps natural gas is such a fuel.

In order to bring gas extraction in Central Asia by 1970 to the level established by the Instructions of the 23rd Congress CPSU, some 700-800 billion cubic meters of gas will have to be moved to Category A plus B stocks, and exploratory drilling in the wasteland regions of Uzbekistan and Turkmenia, which are more difficult to open up, will have to be increased in scale by several times.

It should be kept in mind that this Five-Year Plan will introduce the exploitation of gas deposits which contain hydrogen sulfide and condensate, a fact which will significantly complicate the build-up of gas extraction. Is it possible under these circumstances to count on obtaining supplementary quantities of natural gas on a scale sufficient to replace all the expensive forms of fuel, including gas from underground gasification? Even if it is assumed that this is possible, the question then arises: is it not more expedient to send these supplementary resources of natural gas to the European part of the USSR than to use them in supplanting expensive forms of fuel in Central Asia? For by the time that the gas pipeline from Central Asia to the Center is operating, the effectiveness of use of gas at the Center will be significantly higher than in Uzbekistan.

In this case, from the point of view of the interests of the national economy as a whole, it is proper to add to the expenditures for using natural gas, as a possible replacement for more expensive forms of fuel in Uzbekistan, the economy not realized by using gas from Uzbekistan deposits in other parts of the USSR. The calculated expenditures (specific capital investments plus absolute cost) for using natural gas in Central Asia, taking this economy into account, is 5-8 times greater than the expenditures for extracting Central Asian

natural gas.

But in order to increase the volume of extracted gas, it is necessary to initiate the exploitation of a deposit where conditions are less favorable for development than those, let us say, of Gazli, and with worse indices both for extraction and for local transport of natural gas. In other words, to replace expensive forms of fuel, including gas from underground gasification, it is necessary to develop some new deposit of natural gas; this new deposit will have the least favorable technical-economic indices, for the deposits with the best indices are already being exploited.

This is why, speaking of the expediency of replacing gas from underground gasification, it is necessary to compare its cost with the calculated expenditures (capital investments and cost) of extraction and transport of natural gas of deposits with a less favorable environment and take into account the possible economy in its use at the Center. According to rough calculations, the technical-economic indices of extracting natural gas at such deposits can turn out to be 4-6 times less profitable than those at Gazli.

As is apparent, an economically sound solution to the question of the expediency of rejecting gas from underground gasification, as with other expensive forms of fuel in the Uzbekistan environment, presents a complex problem. At present we do not have the necessary working experience of the gas industry which would permit an adequately sound basis for asserting that in the next few years the substitution of natural gas for expensive forms of fuel in Uzbekistani conditions will prove possible, much less expedient.

This is why, in our view, there is as yet no basis for curtailing the production of gas at the Angren underground gasification station.

At the same time we completely agree with the opinion of the authors of the referenced article regarding the inexpediency of supplementary capital investment for expanding the power station, the more so because many years of experience of underground gasification of coal in the USSR has shown extremely low technical-economic indices for this method of producing fuel.

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25 Sept 67
USSR Ind. Develop No 72

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STATION WHICH GASIFIES COAL UNDERGROUND
IS IMPROVING IN EFFICIENCY

/Following is a translation of an article by A. Zhirnyy, G. Zybalova, and D. Semenenko, entitled "Wrong Conclusions," in the Russian-language periodical Ekonomika i Zhizn' (Economics and Life), No. 6, Tashkent, 1967, pages 63-65./

In the article, "Underground Gasification. Is It Justifying Itself?" by A. Irgashev and I. Ibragimov /in Ekonomika i Zhizn (Economics and Life), No. 7, 1966/, it is correctly emphasized that obtaining fuel gas by underground gasification of coal "is a progressive and very promising trend in the utilization of fuel resources and it has great social significance, for it completely eliminates the heavy work of underground mining." However, in moving over to a determination of the effectiveness of the work of the Angren Podzemgaz (Podzemnaya gazifikatsiya; Underground Gasification/ Station and comparing the station's indices with Mine No. 9, the authors surprisingly come to the conclusion that the prospects for underground gasification of Angren coal is extremely questionable and that, because of this, the growth of the station's productive capacity should be limited.

In comparing the underground gasification of coal with extraction by mining, the authors do not consider that the technical-economic indices of one enterprise or another depend on the scale of production, on their improvement, and on the presence of hidden reserves. Whereas insignificant improvements of technical-economic indices are inherent in the old, long-applied processes, new ones dissolve into a number of hidden reserves, the realization of which permit significant improvements in the indices in a comparatively brief time.

It is appropriate to recall, in this connection, that the Angren station is still the only comparatively large enterprise engaged in

extracting coal by underground gasification. Because of a number of organizational-technical factors inevitable in any new endeavor, mastery of the station's output has been protracted; in 1965 gas extraction reached only 60 percent of that planned. The cost came to 16 rubles per ton of conventional fuel. Incidentally, the cost of the gas has decreased by more than two times in the four years of station operation.

According to VNIIPromgaz [Vsesoyuznyy nauchno-issledovatel'skiy institut promyshlennosti gaza; All-Union Scientific-Research Institute of the Gas Industry] data, when the station's power output is brought up as projected by an increase in scale of production, the cost of gas will be reduced to 11.7 rubles per ton, and with the application of more modern methods to the industrial process which permit raising combustion heat from 800 to 866 kilocalories and reducing underground losses of gas to 6-7 percent, the cost of gas will be lowered to 9.85 rubles.

Now let us compare the technical-economic indices of the Podzemgaz Station and Mine No. 9 in Angren (see Table 1).

Despite the fact that Mine No. 9 is now exceeding the achieved output of the Podzemgaz Station by three times, the cost per ton of natural fuel FOB at the mine has been reduced in the past two years by only 3 kopecks. And by 1970, according to Uzgiprotyazhprom [Uzbekistanskiy gosydarstvennyy institut po proyektirovaniyu zavodov tyazheloy promyshlennosti; Uzbekistan State Institute for Planning Plants for Heavy Industry] data, the cost of coal is to be lowered by 13.3 percent, when it will be 5.23 rubles.

However the coal must be transported from the mine to the GRES [Gosydarstvennaya rayonnaya elektrostantsiya; state regional electric power station] and readied for burning and the ashes from the furnace hauled away. According to the VNIIPromgaz data, the cost per ton of conventional fuel delivered to the boiler of a GRES, including the expenditures for ash removal, was 14.3 rubles in 1965 and will be 12.75 rubles in 1970.

In 1965 the output at the Podzemgaz Station was less than that of the operating mines of Central Asia, and the cost of conventional fuel was higher. However, from year to year, with increased scale of production, the cost, specific capital investment, and, consequently, quoted expenditures per station have been declining steadily. Factual data permits the assertion that in raising the station output to the projected level, even with existing technology, the cost of extracted fuel FOB at the GRES will be lower than at Mine No. 9. Improving the industrial process of underground gasification will enable the station's cited expenditures to be 7.7 percent lower than those in prospect for Mine No. 9.

Table 1

TECHNICAL-ECONOMIC INDICES OF THE PODZEMGAZ STATION, MINE NO. 9, AND OTHER CENTRAL ASIAN MINES

Enterprises	Cost per ton of conventional fuel FOB at the GRES (in rubles	Capital investment per ton of conventional fuel (in rubles)	Quoted expenditures per ton of conventional fuel (in rubles)
PODZEMGAZ STATION			
a) Actual data for			
1964	18.8	86.0	36.0
1965	16.0	62.5	28.5
b) Prospects if output is raised as planned:			
Using current technology	11.7	37.8	19.26
Using improved technology	9.85	34.8	16.81
MINE NO. 9			
a) Actual data for			
1964	14.4	27	19.8
1965	14.3	27	19.70
b) Prospects for 1970	12.75	27	18.2
OTHER CENTRAL ASIAN MINES			
a) Actual data for 1965	14.30	47	23.70
b) Prospects for 1970	12.75	47	22.15

In mastering the station's rated capacity with existing technology, the labor productivity of underground gasification will exceed slightly that expected of Mine No. 9 after its reconstruction, and with improved technology it will be raised by 11.2 percent. This is understandable, for in underground gasification all the engineering operations are conducted from the earth's surface, and the process excludes unproductive labor-consuming operations because of the high expenditure of energy needed by the process.

Let us now examine the balance of distribution of potential heat. In 1965 the Angren Station, in generating 100 tons of conventional fuel supplied at the GRES, expended 211 tons of balance-sheet reserves (that is, taking into account gas fires and loss of gas at contour sections (prikonturnaya uchastok)).

If one deducts the expenditures of electrical power on the station's own needs, then for every 100 tons of fuel delivered to the customer, 337 tons have been expended. In mastering the planned output of the station, the specific expenditure of coal will be almost the same as in 1965, but contemplated advancements in technology will allow reduction of coal expenditures, taking into account the required electrical power, to 233 tons.

It should be noted that high fuel expenditures on the station's own needs stem not only from the specific nature of underground gasification but also from excessively high fuel expenditures in generating one kilowatt-hour of electricity at the Angren GRES, which works on the basis of coal.

In achieving Podzemgaz Station's planned output, the share of gas in fuel consumption at the GRES will not exceed 17 percent.

As the authors indicate in the above-mentioned article, specific fuel expenditures at the Angren GRES consisted in 1965 of 470.5 grams per kilowatt-hour, at a time when the electric-power stations of Mosenergo [Moskovskoye rayonnoye upravleniye energeticheskogo khozyaystva; Moscow Rayon Administration of the Power Industry], which consume combustible-gas fuel, have a specific expenditure of less than 300 grams. If specific fuel expenditures are reduced to the indicated limit, then fuel consumption by the Angren Podzemgaz Station for its own use will be reduced from 37.5 to 24 tons per 100 tons of fuel delivered to the GRES.

But how will the balance-sheet reserves of coal at Mine No. 9 be used? According to the plan for expanding this mine, to be carried out by Uzgiprotyazhprom, losses will consist of 51.5 percent. But if to this is added fuel expended for transport, preparing the fuel for burning, and hauling away the ashes, which is equal to about 2.5 percent of the quantity of fuel delivered to the GRES, and also the fuel expenditure for the mine's own needs (in the form of electricity and coal), which are equal to about 2 percent of the output, then the degree of utilization of the heat potential at the mine will exceed slightly the degree of its utilization at the underground gasification enterprise.

In conclusion, a mistake by the authors of the article should also be pointed out. They have determined the selling price of gas from underground gasification to be 19 rubles per ton of conventional fuel and the selling cost of electrical power used in transforming it into conventional fuel to be 11 rubles. Actually, they are equal, respectively, to 17.6 and 16.8 rubles.

Let us make an elementary calculation. The selling price of gas from underground gasification in 1965 was 2 rubles per 1,000 cubic

meters with a heat-producing capacity of 800 kilocalories per cubic meter. Therefore, the cost per ton of conventional fuel will be equal to

$$\frac{2 \times 7,000}{800} = 17.5 \text{ rubles.}$$

The selling price of electricity in 1965 was 79 kopecks for 1 kilowatt hour, but the conventional fuel expended in producing the electricity was 470.5 grams per kilowatt-hour. Consequently, the cost per ton of conventional fuel "given back" to the station equaled

$$\frac{1,000 \times 0.0079}{0.4705} = 16.8 \text{ rubles.}$$

Thus, it is impossible to agree with the recommendation of Uzgiprotyazhprom about limiting the power produced by the Angren Podzemgaz Station. It would be wiser to speed up mastery of the planned power output. The latter course is dictated by the fact that in our country (including the republics of Central Asia) a sharp deficit in fuel which calls at times for delivery of coal to Angren GRES from other places, is making itself felt.

STAT

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STATIONS OF THE UNDERGROUND GASIFICATION OF COALS

- USSR -

[Following is the translation of an excerpt from the Russian-language monograph Podzemnaya Gasifikatsiya Ugley (Underground Gasification of Coals) by I. A. Turchaninov, Moscow, Gosgortekhizdat, 1961, pp 43-50.]

The underground gasification, in this country, is now at an industrial experimental stage. Low capacity Podzemgas (Underground Gas) stations have been installed in various coal basins and are operating under diverse geologic and mining conditions. Several additional Podzemgas stations and experimental areas are underway.

A number of major underground gasification stations have been designed, largely based on coal deposits of eastern regions of the USSR where there is no local natural gas.

The Moscow Podzemgas Station operates on coals from the Novo-Basovo and Gosteyevo deposits. The gasified coal seam is almost flat, forming extremely gentle folds. It occurs at 40-50 meters below the surface and is 2-2.5 meters thick, with a maximum thickness of 4.5 meters. Its coal has a fairly high ash content, varying in a wide range, with an average of 25-30%. Locally the seam is split up by shale intercalations. It is overlain and underlain by shales and locally by sandstones.

The quality of coal is described by the following average figures: moisture, 30%; ash, 23%; carbon, 31%; hydrogen, about 3%; oxygen, 10%; nitrogen, about 0.5%; and sulfur, about 2.5%.

The lowest heating capacity of the coal is 2,700-2,900 kcal/kg; the total coal reserves for the two deposits are about 18 million tons (metric).

At the present time, the station generates 1,200-1,300 MCM (thousands cubic meters) per day, and equivalent of 400-500 tons of brown coal. The heating capacity of this gas varies from 750 to 900 kcal./cubic meter, the average being over 800 kcal/cubic meter. The total gas production, up to 1960, was over 4,000,000 MCM. The gas is dispatched through a trunk line about 8 km long, to various industries and enterprises of Tula.

In addition to its main product -- gas - the stations's sulfur section processes valuable by-products, such as lump sulfur, industrial hyposulfite, and photographic hyposulfite. The latter is of particularly high quality and its entire output is used in the moving pictures industry.

The Shatskaya Podzemgas Station is located near Tula. Its base, the Shatskoye coal deposit, includes two isolated coal lentils. The largest of the two -- the Western -- is to be gasified first, followed by the gasification of the Eastern. The total coal reserves for the two lentils are 27 million tons. The Shatskaya coal bed usually occurs at 40 meters and is about 2 meters thick. The quality of its coal is about the same as in the Novo-Basovo deposit.

The planned output of this station is 50% higher than for the Moscow station.

The South-Abinsk Podzemgaz Station is located in the South-Abinsk and Aktash sections of the Kiselevsk hard coal deposits, the Kuzbas. The coal reserves with the South-Abinsk section alone have been estimated at 280 million tons. The Aktash section reserves, not adequately surveyed as yet, are not as large. The mining reservation of this station carries 23 coal beds, 0.8-20.0 meters thick, with the majority of beds about 2 meters thick. Over the most of the area, the beds dip at 55-70°, except in the south where they flatten out to 30°. The coal is of the gas generating and boiler quality, slightly caking.

This station was built as a purely experimental enterprise, to study the feasibility of underground gasification of thick to intermediate coal beds, steeply dipping, under the Kuzbas geologic and mining conditions. The fact is that many experts voiced doubt as to the feasibility of a sustained production of a specific gas, under such conditions, especially from thick coal beds. They believed that a collapese of overlying rocks will unavoidably lead to a bridging over of the gasification channel; in addition, if spread as far as the surface, it will break up the air-tight seal of gas-generating horizons and put an end to the technologic process.

Because of the experimental nature of the enterprise, the original daily output was planned as low as 20-25-tons of coal equivalent. No gas pipe lines to the consumers were contemplated. However, all doubts as to the feasibility of sustained production of gas with a consistent composition, accompanied by an adequate gasification of the coal reserves, were dispelled by the performance of the very first experimental gas-generator from the thick Interior-IV coal seam. This seam was 9 meters thick, in the experimental area, and dipped at 68°. Right after the firing-up, in May 1955, the gasification process ran smoothly, generating gas with a heating capacity up to 1,400 kcal/cubic meter. Because of the lack of gas pipes, most of the gas was burned off right at the generator outlet, and only a small portion of it was used for the station itself. Subsequently a pipe line was laid and the gas proceeded to the boiler shop of the large "Taybinskaya" shaft and to the Central Enriching Plant. As it turned out, the collapese of rocks above the burned out space not only did not interrupt the gasification process but promoted its stabilization by preventing the formation of large cavities. Although the spread of the collapse to the surface did cause a partial break in the air-tight seal, rapid measures were devised to restore it. The surface collapse

took place only at the last stage of the gasification operation, when almost all of the coal had burned out.

The present daily output of the station reaches 300-400 MCM, approximately equivalent to 100 tons of coal. Operating with air-blow, the station generates a 800-1,400 kcal/cubic meters gas. Occasionally, the production reaches 500 MCM/day, and better.

As of now, the station supplies with gas a number of industrial enterprises in Kiselevsk: boiler shops of shafts "Taybinskaya" and No. 7, the Central Enriching Plant, a concrete plant, and a bakery. Pipelines to the Kiselevsk Coal Mining Machine-Building Plant and two brick factories are being laid. Additional gas production is contemplated for domestic uses in Kiselevsk.

Plans have been worked out for enlarging the station, to an annual capacity of 2.2 billion cubic meters of gas, which is equivalent to about 300,000 tons of coal. At that capacity, the station will satisfy all fuel requirements of the Kiselevsk industry and population.

The Lisichansk Podzemgaz Station is located at the outskirts of Lisichansk, in the Donbas. It produces a series of 12 thin coal seams with working thicknesses of 0.4-0.8 meters, with the exception of seam k_3 whose thickness reaches 1.5 meters. The seams occur with a variable dip of 30-45°. The ash content in coal does not exceed 15%; the volatile content is up to 40%.

Prior to 1960, this station produced 1000 million cubic meters with a heat capacity of 1,000 kcal/cubic meter. The gasification is done with air blow or with air enriched in oxygen. Some of the oxygen produced by the oxygen plant of the station is diverted to the various industries located near Lisichansk. As by-products, the station isolates rare inert gases argon, keypton, and xenon. This fully utilizes the production potential of its oxygen plant. The present gas production of the station is over 400 MCM/day.

The Kamensk Industrial Experimental Podzemgaz Station is located near Kamensk-Shakhtinskiy, the Rostovskay Oblast. This station is being built to operate on coal reserves of section No. 2, the North-Donets deposit, with two workable seams; the upper, Orekhovskiy, 0.75 meters thick; and the lower, Sukhodol'skiy, about one meter thick. Their dips over most of the area are 45-50°. The coal in both seams is lean (Mark T), with the organic matter containing about 91° carbon and about 4% hydrogen. Their heating capacity is about 8,500 kcal/kg; the average ash content, 12%. The total coal reserves within the station mining reservation is somewhat over 10 million tons.

Inasmuch as this is the first attempt to gasify lean coals under natural conditions, a broad range of experiments is planned at the initial stage of work, at this station. The boreholes are planned to be connected by the electric method, because the thermo-electric properties of lean coals are favorable for such operations.

The planned annual output of the Kamensk station is 365 million cubic meters of gas, which is equivalent to 150,000 tons of high grade anthracite. Subsequently, the output is to be doubled. The gas will be consumed by the various industries of Kamensk.

It should be noted that the small coal mines operating in the Kamensk area were shut down several years ago, because their coal could not be stored for any length of time, due to rapid oxidation, so that its industrial use was limited. At the same time, the local industries consume large quantities of high-grade imported fuel. With the firing up of the Podzemgaz station, it will be possible to replace a considerable portion of the imported fuel by underground-generated gas.

Experimental work at the station is to begin in 1960. After that, the experiments will run parallel to gas production.

The Angren Podzemgaz Station is located southeast of Tashkent. The section of the Angren brown coal deposit alloted to underground gasification, carries a coal seam at depths of 100-200 meters, 150-160 meters on the average, and dipping gently at 5-15°. Its thickness varies in a wide range of 1.6-22 meters, the average being 9 meters. The enclosing rocks are siltstones and claystones. The coals are of a higher rank than the Moscow basin brown coals. Their composition is as follows: moisture, 31%; ash, 16%; carbon, 40%; hydrogen, about 3%; oxygen and nitrogen, 9%; and sulfur, about 1%. Their volatile content is 22-24%; the heat capacity, 3,650 kcal/kg. It is to be noted that the Angern coals are rapidly oxidized in air and turn to a powdery mass. This greatly interferes with their transportation.

The Angren station, when brought up to its full capacity, will be the largest of all operating and building underground gasification stations. Its annual output will reach 2,300 million cubic meters of gas, an equivalent of about 650,000 tons of the Angren coal.

The annual capacity of the initial stage is 1000 million cubic meters; with a heating value of kcal/cubic meter. The first experimental gasifier was fired up in the second half of 1959, and the first thousands of cubic meters of Angern gas were produced.

The Sinel'nikovo experimental area is being built near that town of the Dnepropetrovskaya Oblast. Experimental work is planned here on the conditions and efficiency of underground gasification of the Dnepr basin brown coals. The experimental area carries a single coal seam, at a depth of about 100 meters; its thickness varies greatly, being 4-5 meters on the average for the experimental area. The average ash content is about 20%. Coal deposits of the Dnepr basin are distinguished by their flooding; therefore any method of their production calls for drainage. In addition, the Dnepr brown coals have a high moisture content, up to 55-60%, so that the conditions for their underground gasification will have to be determined. The experimental work is expected to establish the efficient methods and the degree of draingage, also an optimum gasification regimen; after that it may be possible to proceed with the building of underground gasification stations in that industrial area where gas will be applied to most diverse uses.

An experimental area for underground gasification of oil shales is being completed near Kivili, in the Estonian SSR. Its building was

preceded by experiments under laboratory conditions and in small experimental segments, under natural conditions, conducted by the Chemical Institute of the Estonina Academy of Sciences, and by the Kivili Chemical Shale Combine.

In their chemical composition and properties, oil shales differ greatly from hard and brown coals. Consequently, the products of their thermal decomposition in the process of gasification have chemical composition of their own. Their principal components are valuable raw materials -- tars and power gas. The tar contains up to 50% hydrocarbons; up to 30% paraffins and naphthenes, and up to 20% assorted oxygen compounds (phenols, acids, etc). All these tar components are a valuable raw material in the synthesis of many products, such as plastics, polymers, synthetic fiber, detergents, high-grade lubricants, wood-treating antiseptics, tanning fluids, fertilizers, etc.

Gas produced along with the tar contains 5-7% carbon oxide and 9-12% hydrogen, and has a heating value of 700-800 kcal/cubic meters.

At the experimental site, a bed of "kukersite" slates /L. Silurian sapropelitic slates/ occurs at depths of a few to 40-50 meters. It is mostly 2-3 meters thick, split up by barren rock intercalations. The enclosing rocks are limestones. This horizon is almost flat, dipping very slightly to the south. Its organic content is but 20-50%, the rest being represented by limestones.

Two methods are to be tried in producing these oil shales, with application of underground gasification. In the first, the highest grade shale is mined by the conventional shaft method. The low grade shale, whose mining is uneconomical (seams with less than 37% organic content, according to the present specifications) are either not mined at all or else left behind as fill-up material in the mined-out space. These residual reserves are subject to subsequent underground gasification, through boreholes from the surface.

The second method is to gasify the entire oil shale seam, without a preliminary mining of its richest segments. As in coal deposits, the gasification is planned without shafts, with only the operational holes drilled to the horizon. The initial results under natural conditions have demonstrated the feasibility of electric junction of the boreholes.

The experimental area is expected to be completed and ready for underground gasification of the Baltic kuker site slates, in 1961. The main purpose of these experiments is to develop the most efficient method of dry distillation of the organic content in the slate, in the process of underground gasification. This will assure a maximum yield of valuable tars, with a fairly complete gasification of the slate reserves.

/Captions to a selected few photos and diagrams. Photos have not been reproduced for this report./

Figure 12, (p 22): Rig BGS-2 for drilling horizontal channels through a coal seam, from vertical holes.

Figure 13, (p 22): Progress diagram of underground gasification adopted in the Moscow basin.
Air-blow boreholes
Gas outlet boreholes
Junction boreholes
Drilling holes
Outline of the area alloted for gasification.

Figure 14, (p 25): Principal variation of the underground gasification scheme with a preliminary thermal processing of the seam.

Figure 20, (p 34): Air-blow plant of a Podzemgaz station.

Figure 21, (p 36): Central dispatching point of a Podzemgaz station.

10,059

- END -

Improvement of Efficiency of Utilization of Electric Power

For years the Soviet Union has been concerned about the overexpenditure of electric power, particularly by industry, which uses about 65% of the gross production of electricity. Plans to allocate a larger share of the electric power for household use have not been fulfilled because industry continues to require an inordinately large share of the power available. In an attempt to economize in the use of electric power, the Soviets have established norms for consumption per unit of output, have encouraged the modernization of power-intensive technical processes, and the elimination of old and inefficient equipment, as well as policing wasteful uses of electricity. However, the USSR still ranks well below other countries in the world in the efficient use of electric power, as shown in an article in Electrical World, December 1, 1974 (see attached).

US using electricity more efficiently

An update of demographic figures first published in Electrical World in 1971 shows that the United States has made substantial progress in boosting per capita GNP for each kwhr consumed

The growing energy-consciousness of the United States has found voice in the accusation that this country is profligate in its use of energy. The fact that the US, with less than 6% of the world's population, uses about a third of the world's energy has been used to demonstrate this point. But careful analysis of world energy-use patterns refutes this charge—and, in fact, shows the US to be a highly efficient user of both electric energy and total energy.

Data for over 200 countries of all levels of industrialization, drawn from the Series J, No 17 Statistical Papers of the United Nations World Energy Supplies, compiled by A.J. Ramsdell each year since 1960, are presented in Fig. 1. When the ratio of energy use to gross national product for these countries is plotted against their GNP per capita, the United States falls on the curve defining those countries that are most efficient in generating GNP for a given energy input. These "most efficient" countries have the highest GNP per capita at the lowest level of energy use per capita per unit of GNP generated. This appears to be a reasonable measure of efficiency in using energy, especially when comparisons are made among countries which have not had access to "cheap" energy, as well as those that have.

Energy sustains GNP

Two basic aspects of energy use in our industrialized society become evident in Fig 1:

1. For a given "state of the art" of energy application, each level of GNP per capita corresponds to a minimum amount of energy use per capita, below which the level of GNP per capita could not be sustained.

2. Because economies with higher GNP per capita are, inherently, more energy-intensive, the minimum content of energy per unit of GNP becomes greater as GNP per capita increases.

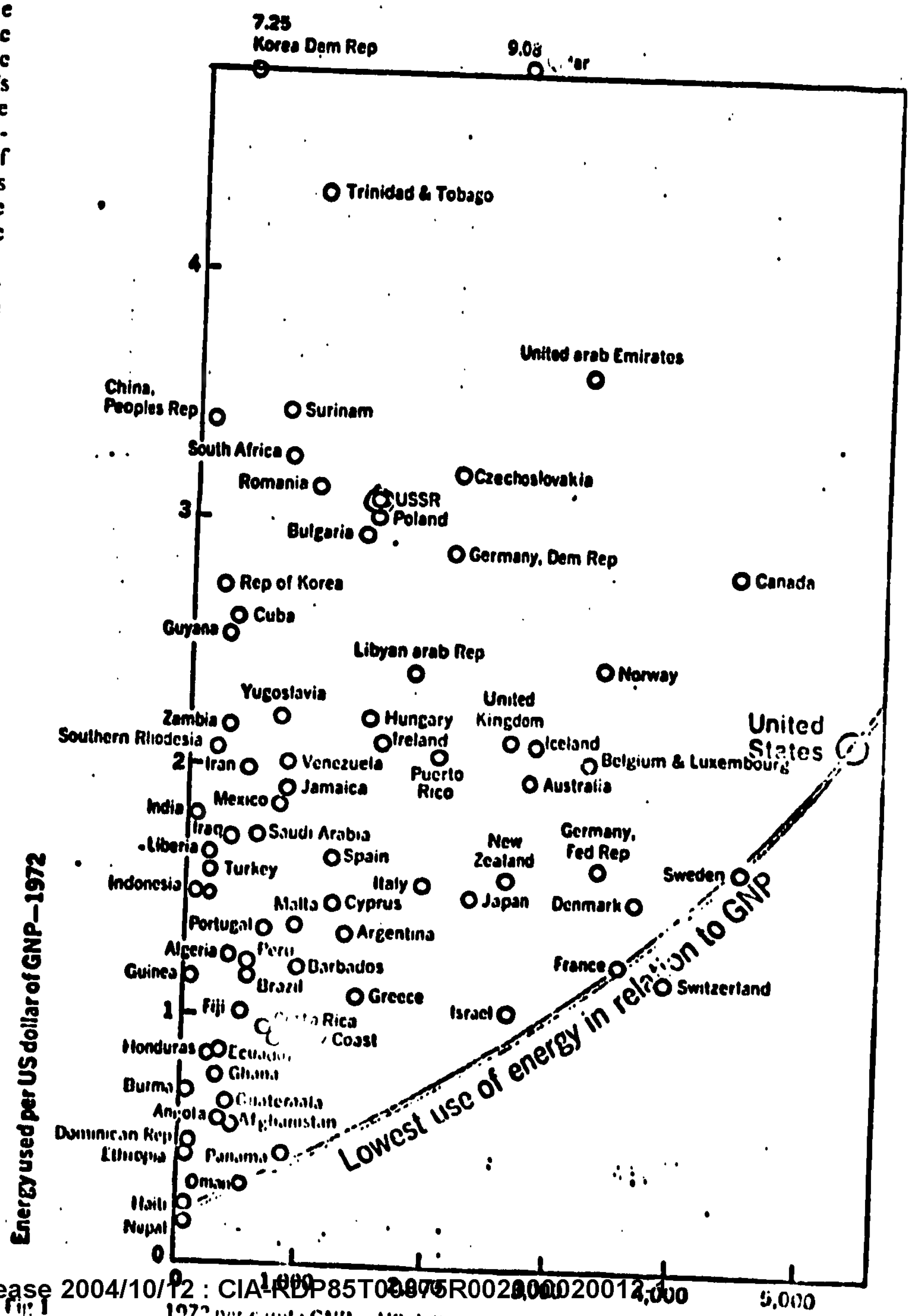


Fig 1

Fremont Felix, Consultant, Gibbs & Hill

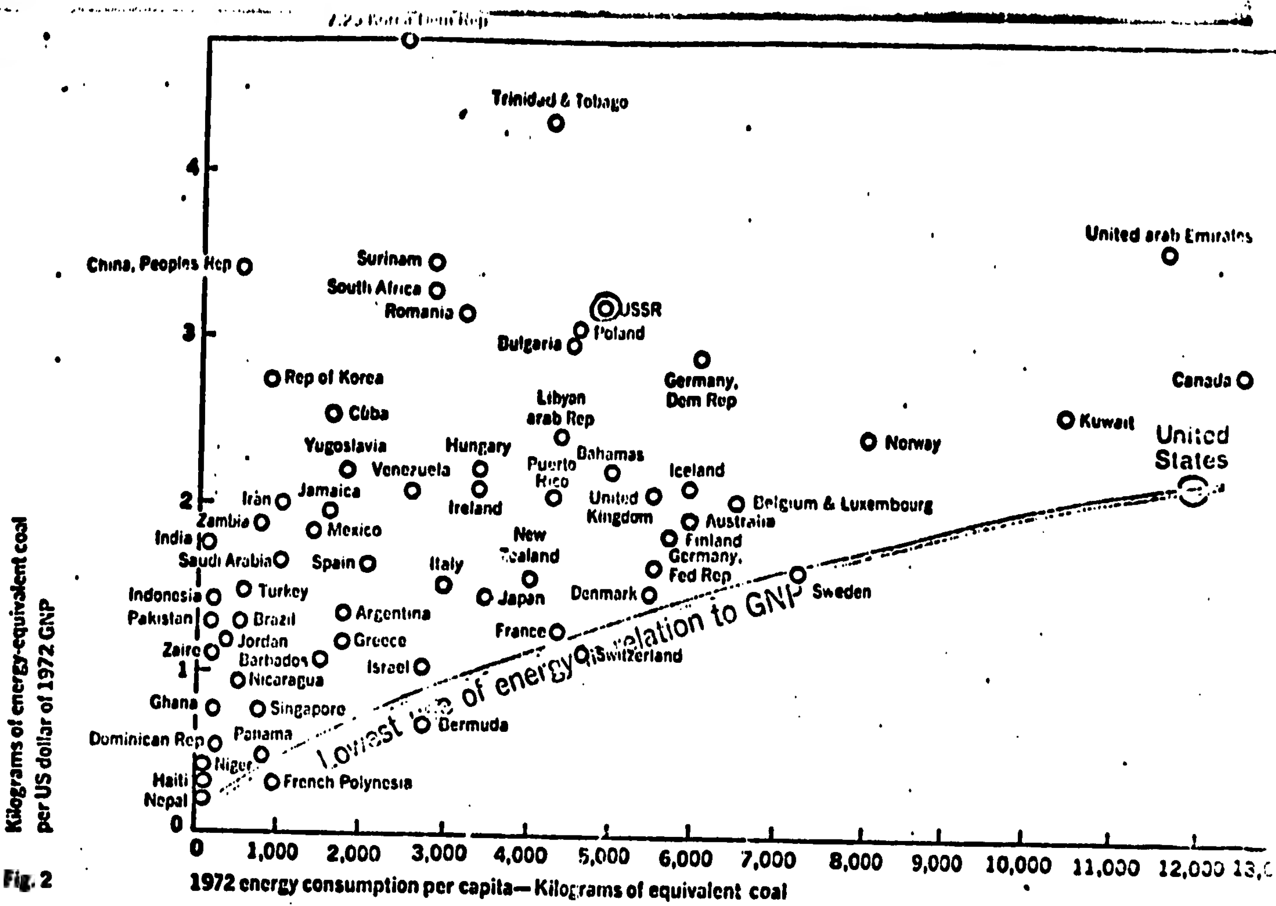


Fig. 2

The question has often been asked of the author: "Why couldn't GNP per capita in the US be sustained with the same energy use per dollar of GNP as, for instance, the economy of West Germany, which is also heavily and efficiently industrialized?" The answer is that this could be done only if the GNP per capita in the US was the same as that of West Germany—instead of being two-thirds higher. And this could be done only if the pay scale in US industry were the same as it is in Germany.

Utmost care should be exercised in assessing or attempting to control the amount of energy that the US can get along on, to ensure that the economy is not seriously disrupted.

This point is stressed here because of the popular idea that conservation of energy by itself can, largely, solve the energy problem. It is, of course, part of the solution, but not more than perhaps 25% of it. The rest can only come from new sources of supply.

Fig 2 presents the same data as Fig 1, except that the abscissa is the per-capita use of energy. The reader will note that the curve of "lowest use of energy in relation to GNP" is clearly defined, without any ambiguity.

This curve raises the question of what France, Switzerland, Sweden, and the US have that places them in the position of generating each dollar of GNP with a minimum use of energy at their respective levels. And, as a concomitant question, what could the less-well-placed countries do to improve their positions in that respect? Obviously, productivity is only part of the answer. The larger reason lies in the mix of the agriculture, industry, and services characteristic of each economy. Per dollar of generated GNP, services use only one-tenth as much energy as the manufacturing industry. Bermuda provides an extreme illustration of this aspect.

Fig 3 is comparable to Fig 2 except that kwhr per capita are plotted against kwhr per dollar of GNP. As in Fig. 2, the curve of lowest use is well defined. However, in Fig 3, which evaluates electrical energy only, the point for the US is far lower than any other.

This is not surprising. The US fits exactly in the "lowest use of energy" classification line, and, since only 25% of the energy used in the US is in the form of electricity, compared to 30% for Western Europe, the US is "lower than the lowest" by approximately the same ratio of 25-to-30. To establish further the validity of the data presented, here, Table I and Fig 4 have been prepared using only data for some "most efficient" countries. Data for 1967 are from *Electrical World*, Jan. 15, 1971; the remaining data are current. GNP-per-capita is on the basis of constant 1972 US dollars.

Productivity of electricity gains

Fig 4 brings out several noteworthy aspects of energy economics:

The curve defining the "lowest use of electricity in relation to GNP" shows that throughout Western Europe and Canada, the "productivity" of electricity, when related to a given level of kilowatthours per capita, improved from 1967 to 1971 by about 10% at the lower end, ranging up to about 25% at the upper end. Further improvement of about 5% at the lower end to about 10% at the upper end occurred from 1971 to 1972. In other words, the productivity of electricity was still growing between 1971 and 1972, probably reflecting the still-increasing efficiency and productivity of electric-powered processes.

This improvement is even more striking in the case of the US, which actually increased its leadership in this area between 1971 and 1972. This could have been simply the result of a lower use of electricity in relation to total energy. However, a separate check (Fig 4)

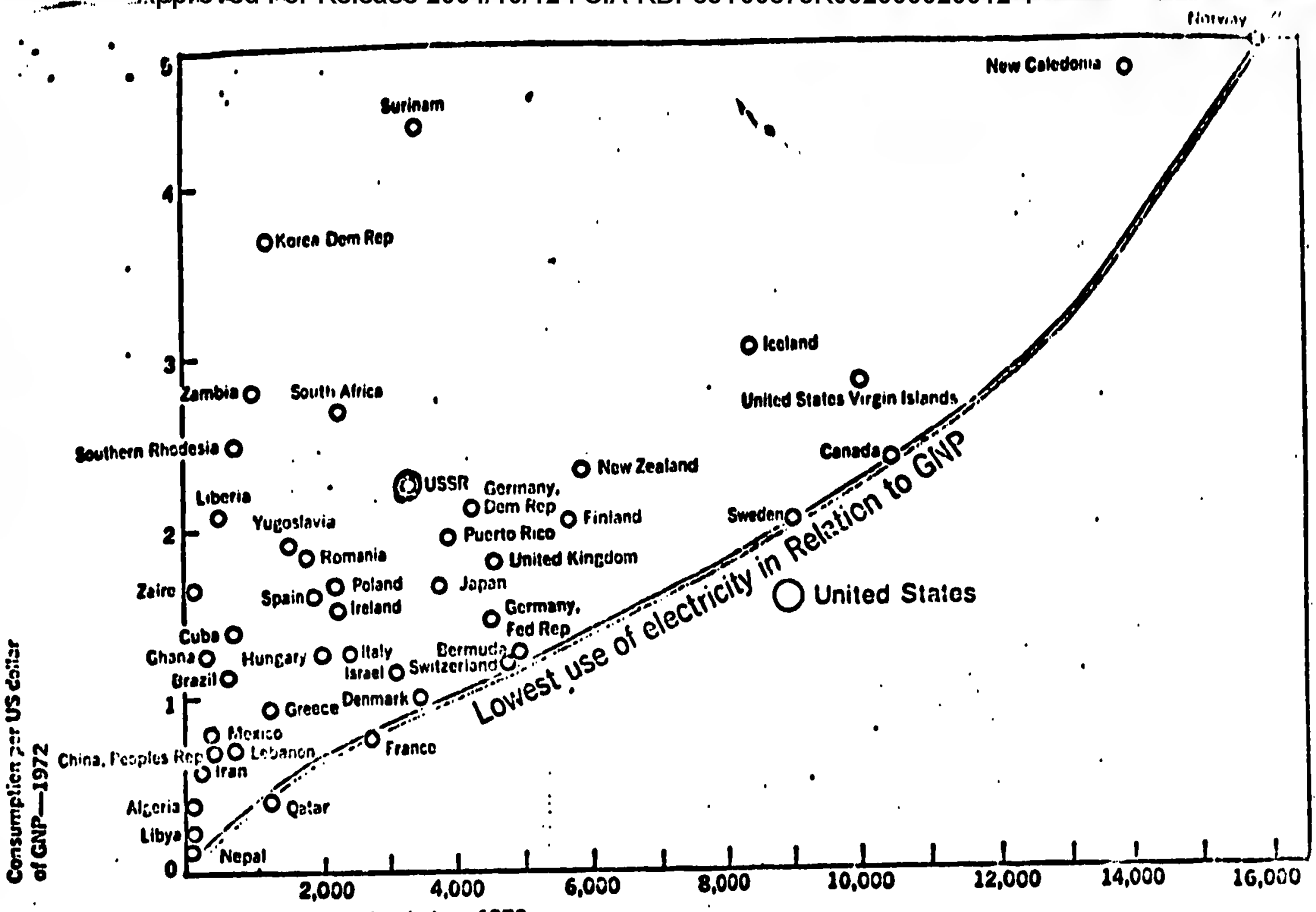


Fig 3

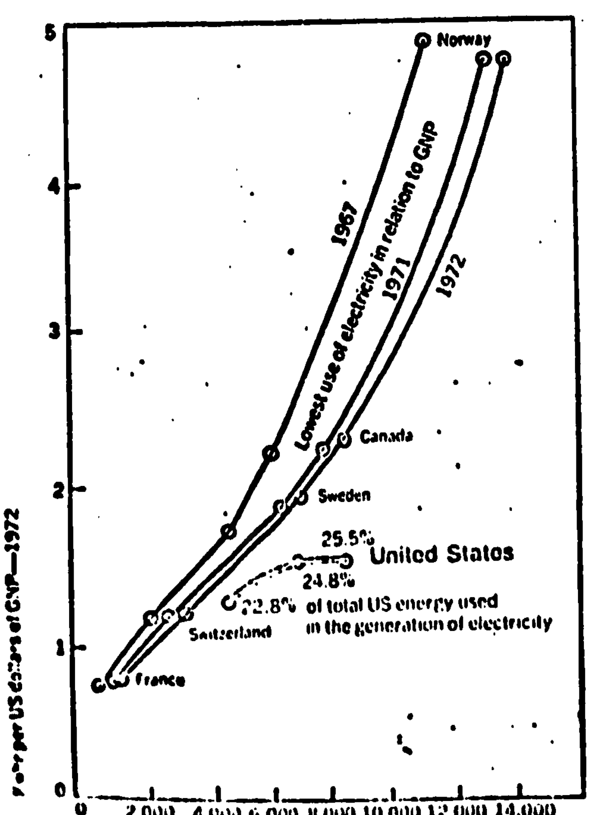
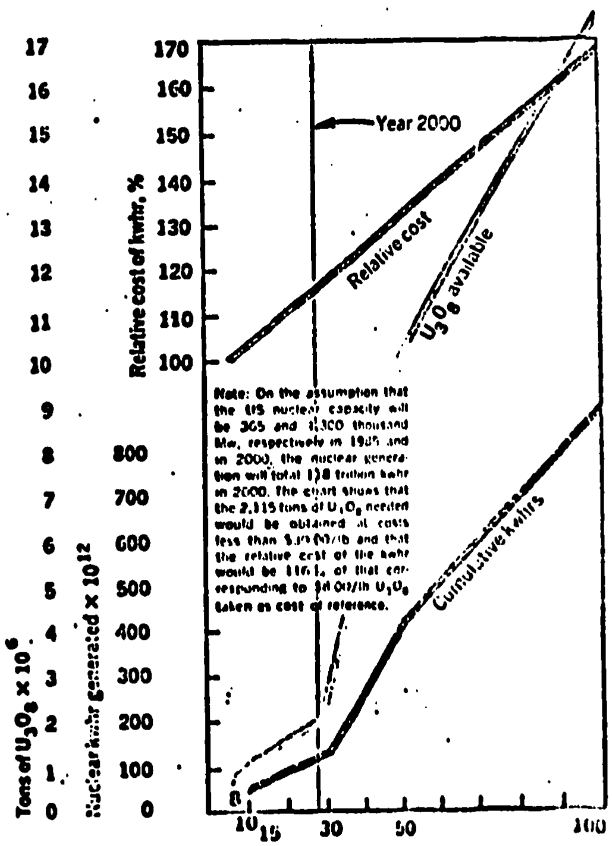


Fig 4



Note: On the assumption that the US nuclear capacity will be 365 and 1,300 thousand Mw, respectively in 1985 and in 2000, the nuclear generation will total 138 trillion kwhr in 2000. The chart shows that the 2,115 tons of U_3O_8 needed would be obtained at costs less than $30/lb and that the relative cost of the kwhr would be 116% of that corresponding to $8.00/lb U_3O_8 taken as cost of reference.

Fig 5

Table I: Comparison of most-efficient electricity economies

	Kwhr/Capita			G.N.P. per capita					Kwhr per (1972) GNP $		
				1967		1971		1972			
	1967	1971	1972	1967$	1972$	1971$	1972$	1972$	1967	1971	1972
France	2,303	2,877	3,043	2,340	2,951	3,360	3,473	3,623	0.780	0.828	0.840
Denmark	2,227	3,137	3,425	2,497	3,149	3,430	3,546	3,674	0.707	0.885	0.932
Switzerland	4,012	4,740	4,972	2,595	3,272	3,640	3,763	3,936	1.226	1.260	1.263
United States	6,630	8,312	8,911	4,040	5,095	5,160	5,334	5,592	1.301	1.558	1.594
Sweden	6,772	8,412	8,988	3,041	3,835	4,240	4,383	4,477	1.766	1.919	2.008
Canada	8,112	9,851	10,513	2,805	3,537	4,140	4,280	4,443	2.293	2.302	2.366
Norway	13,567	15,344	16,056	2,199	2,773	3,130	3,236	3,344	4.893	4.742	4.801

Table II: Impact of uranium prices

Cost of U_3O_8—1973 ($/lb)	U_3O_8 available at that cost (tons x 10^3)*	Electricity producible in Light-Water Reactors (kwhrs x 10^12)	Relative cost of nuclear kwhr (%)	Cost of oil for equal kwhr cost ($/bbl)
8	750	39	100.0	3.25
10	1,050	55	101.5	3.35
12	1,200	65	103.0	3.50
15	1,500	80	105.3	3.65
30	2,150	120	116.5	4.55
50	10,000	430	131.5	5.75
100	17,400	890	175.0	9.15

*Reasonably assured and estimated additional reserves

shows that this improvement in the productivity of electricity was obtained despite an *increase* in the share of electricity in the US energy balance.

Because of the perturbations that the oil embargo of the last three months of 1973, and subsequent energy upheavals in 1974, will undoubtedly have made in the energy-GNP relationship, it is likely that, when we repeat this analysis a year from now, the results will be confused. It is perhaps fortunate, therefore, that the four-year span between these two articles has established the productivity of electricity and demonstrated the improvement still being made.

Uranium supply adequate

If we are to place increasing reliance on electrical energy, we must also increasingly rely on nuclear power. There has been much speculation as to whether adequate supplies of domestic uranium will be available to sustain such a program.

The first three columns of Table II relate the total of assured and estimated additional reserves, and the corresponding amount of electricity producible in light-water reactors, to the 1973 base cost of [illegible] 1973 data.

Demand projections for nuclear generation presented in the March 1, 1974, issue of *Electrical World* show a cumulative total of 108-trillion kwhr by the year 2000. Though these figures, in the author's opinion, appear to be somewhat on the high side, they indicate the need for a cumulative total of about 1¾-million tons of U_3O_8. This is somewhat less than would be available in the under-$30/lb category.

The relatively low impact of the cost of U_3O_8 on kwhr cost (next-to-last column, Table II) results from the fact that nuclear fuel cost is only a minor contributor to overall kwhr cost. In an oil-fired plant, a fuel cost of $4/bbl contributed 47% of the total kwhr cost. When the cost of oil reached $12.50/bbl, total kwhr costs doubled. In a nuclear plant, the cost of uranium oxide at $8/lb represents only 6% of kwhr cost, so that even at $30/lb for U_3O_8, the cost of a kwhr is increased by only 16.5%. A cost as high as $50/lb would add 6-million tons and 20 years of available resources, but would bring the increase in kwhr cost to only 32%.

Energy costs high

The data given permit calculation of the total energy cost for the economy. Taking the data from Figs 1 and 2, each dollar of GNP in 1972 had an associated energy content of 2.14 kilograms of coal-equivalent. Of this, 74.5%, or 1.595 kce, was for nonelectrical energy, leaving 0.545 kce to generate 1.60 kwhr of electricity. This is on the basis of the 1972 average for the US of 0.340 kce per kwhr.

Assuming that energy costs are now equivalent to oil at $7/bbl, which equates to $0.0335 per kg of coal-equivalent, and that the average cost per kwhr is $0.022, the total energy costs associated with $1 of GNP are $0.053 for nonelectrical energy and $0.035 for electrical energy, or a total energy cost of $0.088 per GNP dollar.

Applying this factor to an economy of $1.4-trillion, the total energy costs are $123-billion—$74-billion for nonelectric energy and $49-billion for electric energy. This figure is up from last year's by almost $38-billion, emphasizing the need not only for continued improvements in efficiency, but for a substantial shift from high-cost fuel resources.

Reliance on nuclear power will not only ensure the US of an adequate supply of electricity from domestic sources, but, over the life of each nuclear plant installed, will result in costs equivalent [illegible] a plant firing oil at no more than $5/bbl. ■

ENERGY LOSSES AT PLANTS REPORTED

Moscow VECHERNYAYA MOSKVA in Russian 19 Sep 74 p 2

[Article by N. Bibikov, senior engineer of the Moscow Regional Administration of Power System Management (Mosenergo)]

[Text] A considerable part of the large amount of power used by the capital is consumed by industrial enterprises. It is, therefore, very important that each kilowatt-hour be used to the full. This is the case at most plants and factories. However, an inspection made by Mosenergo indicated facts of impermissible waste.

The Kazhgalantereynoye Production Association (N. Lipikhin, director).

The basic document which mobilizes the collective of the association for saving power-- the plan for organizational and technical measures, was prepared hurriedly. It has no technical-economic justifications; dates for executing the measures were not indicated; and responsible persons were not appointed. How can savings be made with a plan like this and who could pick the winners of the competition or the laggards?

No wonder that there is a great waste of power here. All the lights are on and the equipment operates idly in the shops during the lunch hour and between shifts. Electric motors with excess power are installed at a number of machines. They "eat up" almost 20,000 kilowatt-hours per quarter.

There are also "hidden" leaks of power. The replacement of outdated equipment lags and the change of networks to 380/220 volts is proceeding too slowly. These two measures alone would save 110,000 to 115,000 kilowatt-hours per year.

The Experimental Krasnyy Fakel' Plant of the NIIKhladmash [expansion unknown] (A. Bykov, director).

We will start with the accounting of electric power. The record of its consumption is not kept according to instructions. Daily consumption is not calculated and monthly summaries are not made. In a word, monitoring is poor.

As a result of this, equipment is permitted to idle in the thermal section. The temperature of the electric furnace surface is 2 to 3 times higher than the norm. As a result, the power loss for the quarter is 4000 kilowatt-hours.

The Fifth Mechanical Plant of the Administration of Specialized Enterprises of the Mosgorispolkom (Yu. Goloshumov, director).

The electric cabinet for handicraft production is imporperly insulated and has faulty doors. There are no monitoring meters and the thermal process is monitored visually. This results in a poorer quality of articles and wastes up to 20 percent of power or 3300 kilowatt-hours per quarter. This is enough power to make additional products worth 13,500 rubles.

Winter is coming, the time of the great power consumption and maximum loads on power plants. It is the duty of every manager of an industrial enterprise and each worker to act decisively against waste in power consumption.

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

USE OF POWER RESOURCES CRITICIZED

[Article by N. Mal'kov, USSR People's Control Committee department director: "Expend Power Resources Carefully"; Moscow, Materialno-Teknicheskoye Snabzheniye, Russian, No 4, 1972, pp 9-12]

The five-year plan for the development of the national economy for 1971-1975 anticipates a significant increase in the capacity for the production of fuel and electric power: by the end of the five-year plan it is projected to reach a production of electric power of 1,030-1,070 billion kilowatt hours. Under these conditions the rational use of electric power resources takes on an especially important significance.

Putting planning of expenditure in order, working out organizational and technical measures and introducing advanced electric production processes which sharply reduce the consumption of fuel, heat, and electric power, and the use of secondary electric power resources are the basic ways of ensuring the savings and rational expenditure of electric power resources.

Over the first half of 1971, six billion kilowatt hours of electric power, 8.8 million gigacalories of heat, and 2.7 million tons of standard fuel were saved for the country as a whole. And besides that, as the materials of the check-ups show, there are still serious shortcomings in the work on economically expending power resources.

In planning the expenditure of fuel and electric and fuel power, statistical test standards occupy a great portion as formerly. For example, of the 98 power stations under the USSR Minergo [Ministry of Power and Electrification], 55 do not have technically sound standards for the proportional expenditure of fuel.

In machine building an imperfect method of standardizing the proportional expenditure of fuel and electric and thermal power per

1,000 rubles of gross production is the most widespread. Such standardizing does not reflect the real power capacity of enterprises and depends on changes in the cost of raw materials, materials, the assortment of output being produced, and other factors. Instances of establishing overestimated standards for the expenditure of fuel and electric power are common. Thus, standards for the expenditure of electric power in the production of acetylene, nitron, nitrile, and acrylic acid at the Saratov Chemical Combine of the Ministry of the Chemical Industry were established higher in 1971 than the actual expenditure.

An analogous situation exists in the production of polyvinyl chloride at the Sterlitamak Chemical Plant and chlorophosphate [khlorofos] at the Volgograd Chemical Combine. Proper order has not been arranged in standardizing the expenditure of fuel at the glass plants of the Ministry of the Construction Materials Industry. Thus, at the L'vov and Mineral'nyye vody bottle plants 800-1,100 kilograms of standard fuel are being expended per one ton of output while a total of 404 kilograms are being expended at the Konstantinovka and Odessa plants. In the production of high quality dishes an average of 2,200 kilograms of fuel are expended per one ton of dishes, but at the Gus'-Khrustal'nyy and Kiev artistic glass and the Stryy plants 2,860, 5,450, and 7,200 kilograms of fuel are expended respectively.

In the Ministry of Nonferrous Metallurgy standards for the expenditure of electric power have been established only for the production of magnesium and aluminum, and there are no branch instructions for standardizing the expenditure of fuel and power resources in the production of copper, zinc, lead, cobalt, and other metals.

One of the important conditions for successfully economizing fuel and energy resources is working out and introducing efficient organizational and technical measures. Many progressive power production processes with a closed power balance have been worked out and introduced in scientific research institutes during recent years. In the chemical industry production aggregates for producing weak nitric acid and ammonia using the heat of reaction and waste gases have been successfully operating for several years already.

However, many enterprises are only formally dealing with working out organizational and technical measures for economizing power resources. At the Volgograd Aluminum Plant last year it was anticipated to save a total of 0.5 percent of the electric and approximately 2 percent of the fuel energy, and 3,000 tons of standard fuel with an annual expenditure of 42,000 tons.

Work on economizing fuel and electric power in general has not been organized in the Nizhneodesskoye Drilling Works Administration of the Komineft' Association of the Ministry of the Petroleum Industry. The projected organizational and technical measures for economizing diesel fuel and eliminating losses in drilling wells were unfulfilled. As a result approximately 300 tons of diesel fuel were over-expended. At the Novomoskovskaya GRES [State Regional Electric Power Station] a combined heat and power supply was installed in 1967 designated for providing hot water for the production shops of the Novomoskovskiy Chemical Combine. However, in connection with incorrectly slow rates of converting the systems of heating and ventilating buildings and structures from steam to hot water, equipment at the Novomoskovskaya GRES is operating at a load of only 8 or 9 percent. A total of more than 100,000 tons of fuel has been overexpended for the year.

Many ministries are not giving proper attention to the most important source of economizing fuel and electric power, namely, using secondary power resources.

The Ministry of the Chemical Industry and its branch associations still do not have data about secondary resources present at their subordinate enterprises. According to data of the NIITEKhIM [Scientific Research Institute of Technical and Economic Research of the State Committee of the USSR Council of Ministers for Chemistry] Institute, even in the basic production branches (ammonia, sulphuric and nitric acid, chemical fibers, and soda ash) the level of use of the registered secondary power resources alone in 1970 did not exceed 49 percent.

In the nitric acid industry the use of the heat ammonia synthesis reaction can annually provide an output of more than 2.5 million gigacalories of heat. However, the utilization installations necessary for this are being employed at only three out of 27 enterprises.

The production process for producing phosphorous is quite energy consuming. A substantial reduction in the expenditure of electric power is ensured through the preliminary thermal treatment of the raw phosphorous. That process has still only been organized at four units of the Chimkent Phosphorous Salts Plant. Implementing this measure at all enterprises would permit an annual savings of not less than 100 million kilowatt-hours of electric power to be obtained in calculating the volume of output in 1975. The impact can be increased if secondary waste gasses of the phosphorous ovens are used as a heat source.

The volume of the annual consumption of heat energy by chemical industry enterprises is great. Approximately 70 percent of it comes from heat and electric power stations in the form of steam and hot water. This obligates the consumers to strictly keep the quotas for the return of condensed steam. Nevertheless, the data of the rayon energosbyt [probably energy distribution] administrations is evidence that the quotas are being systematically not fulfilled. Individual enterprises (the Svobodnyy Trud Plant and the Shchekino and Cheboksary chemical combines) are returning from 15 to 30 percent of the established plan. The Nevinnomyssk Chemical Combine, the Cherchikskiy Electrochemical Plant, and the Mogilev Chemical Fiber Plant return no condensed steam at all.

At the enterprises of the USSR Ministry of Nonferrous Metallurgy only 26 percent of the secondary power resources are being used. The Mednogorsk Copper and Sulphur Combine, for example, approximately 60,000 tons of condensate were thrown into the sewage system over the course of an extended period.

At many enterprises of the USSR Ministry of the Petroleum Refining and Petroleum Chemical Industry the output of thermal energy in utilization installations is low. At the Perm' Petroleum Refining Combine the output of heat in waste-heat boilers makes up 1.74 percent of the total expenditure, 2.3 percent at the Voronezh Synthetic Rubber Plant, and 4.2 percent at the Yaroslav SK [Synthetic Rubber] Plant. At the Nizhnekamsk Petroleum Chemical Combine and the Krasnoyarsk and Sumgait SK Plants secondary power resources are not being used at all. Of the 1,200 production furnaces operating in petroleum refining plants, only one third are equipped with heat-waste boilers, and even they are not fully loaded. The same situation exists at metallurgical industry enterprises. Thus, at the Zhdanov Metallurgical Plant imeni Il'ich 42 percent of the steam is thrown into the atmosphere, 35 percent at the Volgograd Krasnyy Oktyabr' Plant, and 27 percent at the Krivoy Rog Plant. The installations for the dry quenching of coke at the Karaganda Metallurgical Combine is operating poorly. Approximately 1.5 million tons of standard fuel is being lost because of the underloading of heat-waste recovery installations for the Ministry of Ferrous Metallurgy as a whole.

Implementing organizational and technical measures for the rational use of power resources is sometimes hindered as a result of disagreements arising between individual ministries. For example, waste combustible gases produced by many chemical industry enterprises can be successfully used at nearby thermal electric power

stations. Meanwhile, individual USSR Ministry of Power and Electrification organizations are not giving proper attention to this question.

Thus, the Nevinnomysskaya and Shchekinskaya GRES's refuse to accept secondary gasses being burned in the burner from the Nevinnomyssk and Shchekino chemical combines. Because of such lack of coordination the Kuybyshev, Navoi, Fergana, and Groznyy plants were forced to plan their own heat-waste installations which would use these fuel resources with significantly less efficiency. At a number of plants producing weak nitric acid, the possibilities for producing 40-atmosphere superheated steam in recovery boilers is not being used because of the absence of consumers.

A turbogenerator for producing 240 tons of steam per hour was put into operation at the Novomoskovskaya GRES in 1968 for satisfying the requirements of the neighboring chemical combine. However, the equipment of the station is operating at a load of only 50 percent at the same time as more than 50 million cubic meters of natural gas are being burned annually in the boilers at the chemical combine.

Some plants are not being provided with natural gas of the corresponding parameters. Only the Kuybyshev Nitrate Fertilizer Plant is overexpending electric power by more than 20 percent for the production of ammonia in connection with the feeding of casing-head gas.

The unsatisfactory use of production capacities and energy consumption of equipment, irregularity in operation, the poor condition of power management, and breakdowns in equipment repair schedules are the basic causes of the overexpenditure of fuel and electric and thermal energy.

In 1971 an overexpenditure of power resources was permitted at many chemical industry enterprises. An especially unfavorable situation developed at the plants of the Soyuzosnovkhim and Soyuzazot associations. In the second quarter of 1971 the Grodno, Dneprodzerzhinsk, and Rustavi chemical combines and the Cherepovets and Vakhsh nitrate fertilizer plants expended 28 million kilowatt-hours of electric power and 18,000 gigacalories of heat above the plan. At the Nevinnomyssk Chemical Combine 28 million kilowatt-hours of electric power and 46,000 gigacalories of heat were overexpended in the production of ammonia for the half year, and at the Cherepovets Nitrate Fertilizer Plant 10 million kilowatt-hours of electric power were overexpended for July alone.

The Zapadnosibirskiy Metallurgical and Azerbaydzhanskiy Pipe Rolling plants of the USSR Ministry of Ferrous Metallurgy enterprises permitted the greatest overexpenditure of fuel.

In a number of ministries work on saving fuel and electric and thermal energy has been poorly organized. Sometimes leading workers of ministries to not attach proper significance to the timely fulfillment of measures for economizing fuel and power resources. In many ministries only the chief power engineers or supply agency workers are occupied with problems of economizing, but the chiefs of the main administrations and production associations poorly know the state of affairs with the use of power at their subordinate enterprises.

As a result the tasks for enterprises in economizing power resources are often established without sufficient knowledge of the real situation in local areas and without consideration of internal reserves. This alone explains the fact that the enterprises of Soyuzkhimvolokno of the Ministry of Chemical Industry was able to fulfill the annual quota for economizing electric and fuel energy for six months of 1971.

Even in August 1971 the Main Administration of the USSR Ministry of Nonferrous Metallurgy set the task of approving plans of supplementary measures for economizing power resources for each enterprise. However, until now the task has not been fulfilled and many enterprises have not presented their proposals for supplementary economizing.

Ministries and departments must in the shortest possible period of time approve technically sound standards for expending fuel, heat, and electric power for the largest production processes, work out measures for maximally enlisting secondary power resources introduction, and put the system of rewarding workers for their fuller and more efficient use in order.

The USSR Ministry of Power and Electrication together with interested departments must prepare proposals about using the waste gasses and heat of chemical and metallurgical industry enterprises and for the collection and return of condensed steam.

Implementing the indicated measures will permit order to be arranged in power use at industrial enterprises, in transport organizations and at the construction of production projects.

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

OPPORTUNITIES FOR FUEL AND POWER ECONOMIES EXAMINED

[Article by A. Pavlenko, USSR Gosplan member: "The Effect of Saving"; Moscow, Pravda, Russian, 24 September 1971, p 4]

Fuel and electric power expenditure norms must be reduced 7-10 percent during the Ninth Five-Year Plan. This is the target set by the 24th CPSU Congress. It is not difficult to calculate the saving which the national economy will obtain as a result of the fulfillment of this target if it is borne in mind that the USSR produced 740 billion kilowatt-hours of electric power in 1970 and will produce 1.07 trillion in 1975. The production of all types of primary fuel will amount to 1.29 billion tons in standard units in 1971.

Intensifying the policy of thrift and making better use of reserves constitute the path which, when followed, will make it possible to satisfy consumer demand for fuel and electrical and heating power more fully. To what should people's control workers and all participants in the competition for economies devote their attention? Primarily to the strict observance of technological discipline in production and the provision of the most advantageous work conditions. Here I should like to mention that the optimal technological conditions usually correspond to the conditions under which power consumption is most economical.

Let us take ferrous metallurgy as an example. A 13 percent reduction in ingot temperature against the optimum when rolling steel doubles electric power expenditure. Violation of the technological instructions for preparing furnace charges with respect to size and weight inevitably leads to overexpenditure of electricity. An underweight charge lengthens the smelting time because it has to be supplemented during the smelting process. Supplementing twice increases electric power expenditure 5-12 percent, while supplementing four times increases this expenditure by up to 20 percent.

As a rule, proportional electric power expenditure declines with the introduction of new and progressive technological methods and improved machinery, instruments, and attachments. Thus, up to 30 percent of all

electric power consumed by machine-building and metalworking plants is expended on mechanical processing of components. But the volume of mechanical processing can be sharply reduced by introducing precision-casting methods (in chill molds, investment molds, wax patterns, and so forth), thereby reducing electric power expenditure 15-20 percent. High-speed milling, drilling, and grinding not only increase lathe productivity by [illegible]-30 percent, but also reduce electric power expenditure 1.3-2 times.

Enormous savings of electric power can be obtained by replacing mercury-arc rectifiers by semiconductor rectifiers in aluminum electrolysis processes and by applying a duplex process for smelting steel in electric furnaces on a molten rather than a solid basis. It is particularly necessary to dwell on electron-ion technology methods, which make it possible to abandon the utilization of high temperatures and pressures in a number of cases. Here electric power expenditure is reduced several times.

Intensified control over the fulfillment of plan targets for new equipment and technology ensures not only a sharp increase in labor productivity, but also large savings of fuel and power resources.

It is necessary to assume control over the course of the introduction of economical new electrical engineering and power equipment with a higher output. The country is increasing its production of power transformers made from cold-rolled steel, transformers with units to regulate voltage when charged, semiconductor power transformers, television and radio sets based solely on semiconductor circuits, static condensers, efficient illuminants, luminescent lamps, low-capacity incandescent lamps, and automatic and semi-automatic lighting control apparatus. All this will make it possible to save electric power the production of which would necessitate burning more than 10 million tons of fuel.

Large savings are obtained from regenerating electric power in railroad transportation (that is, by returning power to the network when electric locomotives are moving downhill and when their motors are operating as generators). Savings from this amounted to 549 million kilowatt-hours in 1970 and 290 million kilowatt-hours during the first 6 months of this year. The task has been set not only of producing new electric locomotives with power regeneration facilities, but also of reequipping the entire existing pool of electric locomotives.

Another reserve for economies is the utilization of secondary power sources in industry. The heat from hot gases discharged from industrial furnaces, the heat from water utilized to cool machinery, the heat generated by some chemical reactions in technological processes, and so forth -- all this is still being utilized on a negligible scale in our country. Measures have now been formulated in the union republics for making fuller use of secondary power sources at existing enterprises, work volumes have been determined, and how many heat-salvaging assemblies are to be commissioned is stipulated by plans. Constant control is also required for this work, which promises large savings for the national economy.

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Wastage of electric power, heat energy, and fuel is still great in industry, transport, and the housing and municipal sector. Specialists have calculated, for example, that approximately 14 million tons of fuel could be saved during the 5-year plan period by improving the heat insulation of steampipes and equipment utilizing heat.

Proportional fuel expenditure at the country's power stations amounts to 359 grams per kilowatt-hour of power produced. By 1975 this figure must be reduced to 340-342 grams. This is apparently not such a large reduction, but the fulfillment of this target contained in the 24th CPSU Congress directives will make it possible to save more than 20 million tons of fuel during the 5 years.

Reductions in electric power expenditure on power stations' own needs and in losses in electricity networks also constitute an important source of economies in the power industry. Maintaining constant voltage and frequency of current ensures not only savings in electric power, but also increases in labor productivity and reductions in output wastage, particularly in the textile industry.

Of the measures leading to large savings of heat energy, I would like to dwell on another two. A 20-percent increase in the volume of condensate returned from enterprises to thermal electric power plants over the volume last year (and this is perfectly feasible) would make it possible to save an annual 5 million tons of fuel. A reduction of 6-8 degrees in the temperature in industrial and administrative premises on days off, with a subsequent return to the norm, would save one million tons of fuel.

As you can see, there are great possibilities for saving fuel and electrical and heat energy. The significance of this work for a new upsurge in our economy is also great. This is stressed yet again in the CPSU Central Committee resolution "On Further Improving the Organization of the Socialist Competition."

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Gasification of Solid and Liquid Fuel

The USSR has been conducting research on the production of high-BTU gas from coal but reportedly is not as far along as the US.[a] A pilot plant for coal gasification is reported to be located at the Institute of Mineral Fuels, USSR Academy of Sciences, Moscow. The availability of large reserves of natural gas in the Soviet Union has been offered as an explanation for the limited effort to date.

An expanded research and development program may be planned for the future, however. A recent article on the 10th Five Year Plan (1976-80), authored by two members of the USSR State Planning Committee, stated that "it is necessary to expand the scale of scientific research and development work [on the gasification and liquefaction of coal] with a view toward establishing in the future a new branch of the fuel industry."

a/ Soviet underground gasification of coal, which yields a low BTU gas, is discussed in a separate statement.

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

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Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

Combustion of Coal/Slurry Mixtures

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[redacted]

A June 1973 article in the Soviet press claimed that combustion of coal slurries had been successfully tested under industrial conditions and that commercial application had begun. A likely site for industrial tests would be the Belovo electric power plant (Kemerovo Oblast), which is supplied with coal slurry by pipeline.

REFERENCES: A. Krichko, article on hydraulic transport of coal, Pravda, 7 June 1973 (copy of translation attached).

[redacted]

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HYDRAULIC TRANSPORT OF COAL DISCUSSED

[Article by doctor of technical sciences, director of the Institute of Fuel Minerals A. Krichko and secretary of the party bureau of the Institute, candidate of technical sciences G. Delyagin; Moscow, Pravda, Russian, 7 June 1973, p 3]

We read in Pravda for 10 May the correspondence "Beat an early retreat," devoted to development of hydraulic coal mining in the Soviet Union. We agree with its authors, the hydraulic method is very promising.

The results of many years' operation of hydraulic shafts, developed during the past 10 years, convincingly demonstrated the advantages of the new techniques. The manifestation of conservatism, and partially the "exaggerated promises" and errors in the designs, as are justifiably mentioned in the letter, may be explained by the serious lag of hydraulic mining from the promising plan adopted in 1962. But hydraulic coal mining is not just a new method. It must be considered as an integral part of the fuel-energy or fuel-metallurgical complexes, which connect the mine, pipeline transport of the coal slurry and the consumer.

An important element of such complexes is hydraulic mainline transport of fuel in the form of a stable highly concentrated coal slurry. Expenditures for hydraulic transport of large masses of coal from Siberia to the center of the European USSR are 30-40 percent less compared to rail shipments. Hydraulic transport is especially economical for easily self-ignitable coal of the Kansko-Achinskiy Basin.

Use of the complexes will make it possible to completely eliminate losses of coal during transport and storage and to reduce pollution of the land, water and air basins by coal dust, ash, stagnant water, and surfur and nitrogen oxides. The high economy of such complexes was confirmed by a design, carried out in 1966 by the institutes of the ministries of the coal industry of the USSR and of our engineering and electrification of the USSR by assignment of the State Committee of the Council of Ministers of the USSR on Science and Technology.

The method of obtaining highly concentrated suspensions, developed by the common efforts of the Institute of Fuel Minerals, VNIIGidrougol' [Vsesoyuznyy nauchno-issledovatel'skiy i proyektno-konstruktorskiy institut dobychi uglya gidravlicheskim sposobom; All-Union Scientific Research, Planning and Design Institute of Hydraulic Coal Mining], and UkrNIIGidrougol' [Ukrainskiy nauchno-issledovatel'skiy i proyektno-konstruktorskiy institut dobychi uglya gidravlicheskim sposobom; Ukrainian Scientific Research, Planning and Design Institute of Hydraulic Coal Mining], and their ignition in an air flow has been successfully tested under experimental industrial conditions. Introduction of it into industry has begun.

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Mechanical Coal Cleaning

In 1973, the USSR mechanically cleaned 323 million tons of raw coal out of a total production of 668 million tons. About four-fifths of the coal is processed at plants under the jurisdiction of the Ministry of the Coal Industry and the remainder in coke-chemical plants of the Ministry of Ferrous Metallurgy (see Table 1). There are more than 150 coal preparation plants in the USSR.

The 1970 plan provided for 23% of the coal preparation to be carried out by heavy media separation processes (about the same percentage as in the US), but the actual percentage for 1967 was only 14% (see Table 2). The USSR employs centrifugal processing at the Sholokhovskoy coal preparation plant in Rostov Oblast. Research and development work on coal preparation in the USSR is conducted at a number of installations including the All-union Scientific Research Institute for Coal Preparation and Coal Briquetting in Moscow, the Ukrainian Scientific Research Institute for Coal Preparation in Lugansk, the Kuznets Scientific Research Institute in Prokop'yevsk, and the Institute of Mineral Fuels of the USSR Acadamy of Science in Moscow.

The USSR is reported to be ahead of the US, in some respects, in the field of coal preparation. However, lags have been noted in coal processing equipment -- coal driers,

in particular. Moreover, the USSR obtained help during the 1960s from a French contractor in introducing heavy media processing. Under a technical and economic cooperation agreement signed in 1973 with Ruhrkohle A.G. of West Germany technical data will be exchanged on the removal of sulfur from coal.

Table 1

Mechanized Coal Preparation in the USSR, 1973[a]

	Million tons
Total raw coal cleaned	323
At mine plants	262[b]
At coke-chemical plants	61
Total cleaned coal produced	274
Concentrates	194[c]
Middlings & fines	80[d]
Preparation losses	50[d]

a/ Excludes mechanical screening.
b/ Of which 103 million tons was coking coal.
c/ Of which 71 million tons was coking coal.
d/ Estimated.

Table 2

Methods of Coal Preparation in the USSR

	1967	1970 (Plan)
		Percent
TOTAL	100.0	100.0
Heavy Media	14.3	23.0
Jigs	34.8	34.0
Launders	27.7	22.0
Flotation	8.0	8.0
Concentrating Tables	0.2	0.4
Other Methods[a]	15.0	12.6

a/ May include hand sorting.

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Ministry of the Coal Industry of the USSR, Ugol'Naya Promyshlennost' SSSR (Coal Industry of the USSR) 1917-1967, Moscow 1969, pp. 288-309.

Blagov, I.S., Razvitiye Obogashcheniya Ugley v SSSR (Development of Coal Preparations in the USSR) Moscow, 1968.

Long-Distance Hydraulic Transportation of Coal Through Pipelines

The USSR utilizes pipelines to transport coal but the volume is small (about 1.5 million tons per year) and the distances involved are relatively short. One coal pipeline that has been mentioned in the Soviet press is a 10-kilometer pipeline that supplies coal from the Kuznets Basin to the Belovo electric power plant in Kemerovo Oblast. It has also been noted that coking coal is shipped by pipeline to the West Siberian steelworks in Novokuznetsk, probably from the Baydayevskiy-Severnaya hydraulic coal mine (a distance of 10-kilometers), and possibly from other mines. In the late 1950s a 60-kilometer pipeline was reportedly designed to ship coal from a mine in the Ukraine to the Dobrotvorskaya electric power plant in L'vov although evidence is lacking that the project was completed.

Plans for transport of coal by pipeline over longer distances have recently been discussed in the Soviet press. Scientists in Khar'kov are said to have developed a hydraulic transport system for delivering 4.7 million tons of coal per year to an electric power plant 430 kilometers from the mine. Also, a 1,000-kilometer pipeline for transport of 8 million tons of coal per year from the Kansk-Achinsk coal field in Siberia is said to be in the design stage.

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TRANSPORT OF COAL VIA PIPELINE REVIEWED

July

Moscow MOSKOVSKAYA PRAVDA in Russian 21 Aug 74 p 3

[Article by N. Mikhaylov]

[Text] A transcontinental pipeline was designed by Soviet scientists and specialists for transporting coal by hydraulic means from the Kansko-Achinsk field to the center of the country. The water-coal mixture will travel the 1000-kilometer route at a speed of 25 meters per second. It was calculated that this will save 19 million rubles in transporting 8 million tons of coal per year.

The five-year plan specifies a balanced development of all types of transport. Special attention is being given to pipeline transport. It is sufficient to note that the length of the pipeline network in the USSR will reach 150,000 kilometers in 1975 and for general use will exceed the length of railroad lines.

From a narrowly specialized use, mainly for pumping gas, petroleum and petroleum products, pipeline transport is being converted to a most efficient and promising industry. Pipelines with water transport 150 million cubic meters of various solid materials in our country every year.

New, more powerful pipelines are being planned which will be able to transport up to 20 million tons of coal per year. Khar'kov scientists, for example, developed a hydraulic transport system for delivering 4.7 million tons of coal to an electric power plant 430 kilometers from the mine.

The original Lilo pneumatic pipeline has already been operating for several years in Shulaveri in the Georgian SSR. It delivers gravel from a pit to a reinforced concrete plant 2 kilometers away. This pipeline was created by Moscow and Georgian specialists. The pipeline is controlled by only one man, the dispatcher. Loading, unloading, regulation of speed and air pumps are automatic. This provides the high efficiency of the transport and a saving of construction materials. The pipeline brings the enterprise a saving of about 400,000 rubles per year. A second pipeline, 45 kilometers long, is being planned. Over 30 author's

certificates were obtained for the unusual route. It is patented in such developed capitalist countries as England, the United States, France, the FRG and Japan.

It is planned to build such pipelines in Moscow and Leningrad. For Leningrad, in particular, it is planned to build a pneumatic pipeline 10 kilometers long for carrying garbage and rubbish. Ten-ton containers will travel through the 1.2 meter diameter pipelines. This will save over 200,000 rubles per year and free a great number of trucks. A similar pipeline is planned for Moscow.

Pipelines are especially advantegeous for undeveloped regions of the country where large mineral deposits have been discovered. This type of transport can be used for all freight. A number of such pipelines are already in operation in our country. They supply ~~400,000~~ 4,000 tons of coal per day to electric power plants.

Solid materials can be transported in special capsules and containers. Practice has shown that in such cases natural gas can also be used in addition to compressed air as a working medium.

Plans are being developed for pipeline passenger transport. A capsule car will travel 70 to 80 kilometers per hour in a metal, plastic or reinforced concrete pipe of large diameter somewhat smaller than a modern subway tunnel. It will start, stop and have its doors opened automatically. Special equipment will regulate the circulation of air and its pressure in the cabin. The power required for moving the air in the pipeline is very great for capsules at high speeds.

The problem will be solved by using a car on a layer of air. Friction will be reduced sharply, fuel consumption will decrease and the motion will be smooth. When the delivery of air from the front to the rear of the capsule stops, the capsule will begin to act like a piston, its speed will decrease considerably and ordinary brakes can then be used. If part of the air is pumped out of the pipeline, the train will start moving in the rarified space at a speed close to that of sound.

Pipelines have a great future. This is why scientists of a number of the largest scientific research institutions in the country are thinking about them.

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Hydrotechnical Construction in Severe Climatic Conditions

The Soviet Union has built two hydroelectric powerplants in Siberia, under permafrost conditions, which required unique construction and engineering developments. The Vilyuy hydroelectric station is on the Vilyuy River, about 1,000 miles northeast of Irkutsk, and has a capacity of 308 MW. The first generating units were put into operation in 1967. The Khantayka hydroelectric station is on a tributary of the Yenisey River, on the Taimyr Peninsula, about 100 miles south of Norilsk. It began operation in 1970 and has a capacity of 441 MW. Details of the operating experience at these plants are not known. The Soviets are beginning construction of a third hydroelectric powerplant in a permafrost region, the Kolyma station, in Magadan Oblast in the Soviet Far East. They plan to build additional powerplants in East Siberia, above the Arctic Circle, under similar conditions. For this reason they are interested in new methods of solving the problems involved in construction of hydroelectric powerplants under severe climatic conditions.

NEW SIBERIAN POWER GIANT TO SUPPLY DIAMOND TOWN

Damming the Vilyui river, deep in the forests of Northern Siberia

WITHIN two years, a new hydro-electric power station on the big River Vilyui will be supplying the Soviet Union's cheapest current to the Siberian diamond town of Mirny in Yakutia.

The Vilyui river was dammed last week, and the 700-yard long structure will continue to grow until it reaches some 90 feet in height. Behind it a lake 250 miles long will form, but in this remote region that will involve moving only one village—Tuoi-Khaya—with a population of 300.

In 1966, the dam, the power station and a by-pass canal—to enable timber to be floated through—will all be completed.

Work started on the site only four years ago, in conditions of permanently frozen earth, dense, roadless forests and a climate where winter, with temperatures as low as minus 94° F., reigns for seven months a year.

The by-pass canal had to be cut in granite rock on the left bank of the Vilyui.

On the right bank a shaft 90 feet deep was driven through the granite, reaching below the level of the river bed. The tunnellers are now enlarging it at the bottom to provide space for the underground power house.

The shattered rock from the shaft and by-pass canal is being used instead of concrete to fill the dam.

The project is headed by Evgeny Batenchuk, who helped to build the Irkutsk power station.

A small, modern town has already sprung up on the site.

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Soviet Weekly, 13 Jan. '73 p1

The seventh and last unit of the Ust-Khantai power station, in the Taimyr Peninsula, far inside the Arctic Circle, started up at the end of the year, bringing it to its designed rating, 441,000 kW.

That will provide 2,000 million units of power a year for the mines and factories of Arctic Norilsk, the port of Dudinsk at the mouth of the Yenisei, the copper and nickel mines of Talnakh, and the homes of geologists, miners, fishermen and reindeer breeders over a wide area of the Far North.

Round the power station, on the River Khantaika, has grown up a fine modern town, Snezhnogorsk – "Snowmount."

Unexpectedly, the high street is called 68th Street, because it runs along the 68th parallel.

And Snowmount is built and equipped to stand the weather that implies – blizzards that rage for days on end, gale force winds, and temperatures that fall in winter to more than 60 degrees below and soar in the short summer into the eighties.

The whole place, including the power station, stands on permafrost, which has entailed a great deal of engineering ingenuity, the use of frost-resistant concrete, etc.

The chutes that take water from the dam to the turbines are cut through 130 feet of solid rock!

... in the Arctic

THE seventh unit of the Ust-Khantai hydro-electric station on the Taimyr Peninsula in the Soviet Arctic went into operation at the end of December and the world's northernmost hydro-electric station reached its design capacity of 441,000 kilowatts.

The electric power which the River Khantaika supplies goes to the mines and factories of the Norilsk mining complex, to Dudinka, the seaport on the River Yenisei, to the rich Talnakhski copper and nickel deposits and to the townships of geologists, miners, fishermen and deer-breeders on the Taimyr Peninsula.

The main street in Snezhnogorsk, a modern township of construction and power workers is aptly named "Sixty-eighth Parallel." In practice, this stands for snow storms lasting for days on end, winds of gale force and frosts of more than 60° Centigrade.

It was not only the severe natural conditions that the construction workers had to overcome. Because a hydro-electric station had never been built in permafrost conditions before, new engineering problems had to be solved.

Nikolai Ten, chief engineer of the Ust-Khantai project, believes that the experience gained will find wide application in building hydro-electric stations on the Kolyma, Lena, Yenisei and other Siberian rivers.

What is beyond doubt is that Soviet engineers have an unrivalled experience in working in permafrost conditions.

Soviet News, 23 Jan. '73
p.37

POWER IN FAR NORTH -- Moscow, Sel'skaya Zhizn', Russian, 24 Dec 72, p 4

At the world's northernmost power station, the Ust'-Khantayskaya GES [Hydro-electric Station], the seventh and last unit of 63,000 kilowatts has been put on the line ahead of schedule. The capacity of the station is now at its planned level -- 441,000 kilowatts...

The station has already produced over a billion kilowatt hours of electrical energy. Over two 160-kilometer transmission lines laid in the Taymyrskaya tundra, this power goes to the mines and plants of the Norilsk Mining-Metallurgical Combine, to construction areas of Dudinka...

"The experience acquired in building the station will be widely applied in the erection of new hydro-electric facilities on the Yenisey, Lena, and other Siberian rivers," said N. Ten, chief project engineer of the Ust'-Khantayskaya GES. "This is the first hydro-electric station of the underground type to be built in the east of our country."

Progress Report From the Khantayka Power Station Construction Project

The seventh generating unit of 63 thousand kilowatts has been installed at the Ust'-Khantayka power station. The station has now reached its rated capacity of 441 thousand kilowatts.

In the spring of 1963 a helicopter landed the first construction crew on the uninhabited shore of the Khantayka, a Yenisey tributary. The station's first generating unit went into operation in November 1970.

The station has already produced over a billion kilowatt hours of electric power. The electricity is transmitted along two 160-kilometer power lines through the Taymyr tundra to the mines and factories of the Noril'sk Mining/Metallurgical Combine and to construction sites at Dudinka.

Sel'skaya Zhizn'
24 December 1972
Page 4 (Abridged)

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UDC: 621.311.21.002.2(24)

NEW TECHNIQUES USED AT KHANTAYKA DAM

[Article by V.M. Plotnikov and A.I. Golyshev, engineers: "The Ust'-Khantayskaya Underground Hydroelectric Station"; Moscow, Gidrotekhnicheskoye Stroitel'stvo Russian, No 9, 1971, pp 5-7]

The construction of the Ust'-Khantayskaya GES [Hydroelectric Power Station] began in 1963, in an inaccessible area which was not inhabited at the time.[1] The basin of the Khantayka River is above the Arctic Circle, in a sparsely populated forest tundra zone with large expanses of permafrost and sections of melting, slushy ground. The frozen ground has a temperature of up to -3 degrees Centigrade. The depth of the seasonal melting is 2.5 meters.

The region has a subarctic climate, with severe, long winters and short, comparatively warm summers. The average annual air temperature fluctuation amounts to 95 degrees C (from -63 degrees C in February to 32 degrees C in July). Average annual air temperature is -8 degrees C. Snow comes in the first part of October and does not completely melt until the latter part of June.

Most of the freight for the construction project was delivered during the short navigation season (an average of 90 days) on the Yenisey and Khantayka rivers.

The main installation is located on the channel of the Khantayka River, on a dolomite seam 100 meters thick. Both the left and right banks are low relief lake and swamp terrain.

There are no useful mineral deposits, populated areas, agricultural land or known archeological sites in the area to

The stone fill channel dam (a maximum height of 65 meters) has a moraine material core. Excavated stone is attached on the upper and lower faces. There is a reinforced concrete tunnel at the base of the dam. This is for the cement grouting work. The cement curtain grouting is 30 meters deep in the river channel.

The earthfill dam on the left bank is a direct continuation of the channel dam. It is 1,800 meters long and up to 11 meters high. The base of this dam is dolerite, tallus and permafrost moraine soil. The earthfill dam has a mixed profile with a core made from moraine soil, and an upper and lower face made from gravel-pebble materal.

The right bank dam is located 4 kilometers from the channel dam. It is 2.5 kilometers long, and has a maximum height of 30 meters. This dam also has a mixed profile with a moraine core and faces made from gravel-pebble material with sand added. The dam base is tallus , clay, and sandy loam of lake and glacial origin. On freezing this ground swells, and when it thaws out it turns to a running sand (quicksand) with a very low load bearing capacity.

The spillway installation on the delivery canal, the main spillway, and the outlet canal are located in an excavation up to 40 meters deep, on the right bank. The spillway delivery canal is also the delivery canal for the powerhouse.

The spillway is curved with two 20 meter discharge openings with vertical lift gates. The gates are lifted by a 560 ton capacity moving gantry crane. During the temporary operation of the station, when the reservoir is filled to intermediate level, the main spillway is not used. Water is discharged through the foundation slab.

The water intake (Figure 2) is a reinforced concrete installation with seven right angled water scoop openings. It is equipped with trash collecting screens, repair gates, and a rapidly closing vertical gate for operational purposes.

[illegible] closed above-water part of the intake houses individual winches for operating the gates and an overhead traveling crane with a capacity of 2x37.5 tons. The water intakes are joined to the turbine chambers by seven tunnel penstocks with a diameter of 6 meters each. The vertical sections of the penstocks, which connect to the intake, have reinforced concrete linings. The lower horizontal sections are metal encased in concrete.

The GES building (Figure 2) is an underground type located in the right bank. The tunnel under the machinery hall is 140 meters long, 20 meters wide, and 38 meters high, if the outlet pipe is included, the total height of the excavation is 52.5 meters. The machinery hall dome is 1 meter thick reinforced concrete. Rotating blade turbines (PL60/5A-VM-410x type) and SVV 780-/180-32 generators will be installed in the machinery hall. All equipment in the machinery hall will be delivered by truck through a transport tunnel leading to the installation area. The machinery hall will be serviced by two electric traveling cranes with a capacity of 150/30 tons.

The outlet pipes are conical with a cylindrical curve, a long diffuser with a reinforced concrete lining, and metal lining at the end of the cone. Sliding gates close the outlet pipes for repairs. The repair gates are operated by a moving crane with a capacity of 2x40 tons.

The outlet is built into a steep bank 58 meters high. The station control and transformer building and transformer area are built on top of this bank, above the machinery hall and are connected to the hall by two shafts.

In addition to its overall economic advantages from the point of view of the geological-topographical conditions, the underground layout of this project is also best suited to specific conditions in the north. This layout will allow positive temperatures year around in the machinery hall. This will ensure continuous excavation,[2] concrete pouring, and installation work (regardless of unfavorable temperature and weather conditions outside).

The ORU-220 is located on the right bank of the delivery canal. It is planned to have 220 Kv transmission lines (LEP).

Approved For Release 2004/10/12 : CIA-RDP85T00875R002000020012-1

The volume of work for the project amounted to the following: 1,006,000 cubic meters of soft ground, including [illegible],000 cubic meters from underground, 4,578,000 cubic meters of earth and rock fill, including 1,181,700 for the main dam, 230,000 cubic meters of concrete and reinforced concrete, 2,337,000 cubic meters of stony ground and 22,000 tons of metall items.

Preparatory work began in 1963, in 1965 tunnel work began. At the same time preparatory work was underway on temporary housing, and support facilities. In October 1967 the channel dam was completed, and in 1970 work was completed on the intake head of the first section of the project, the reservoir was filled to the intermediate level, and the first two units were put into operation. The electricity is carried over the first link of the 220 Kv IEP, constructed in 1969.

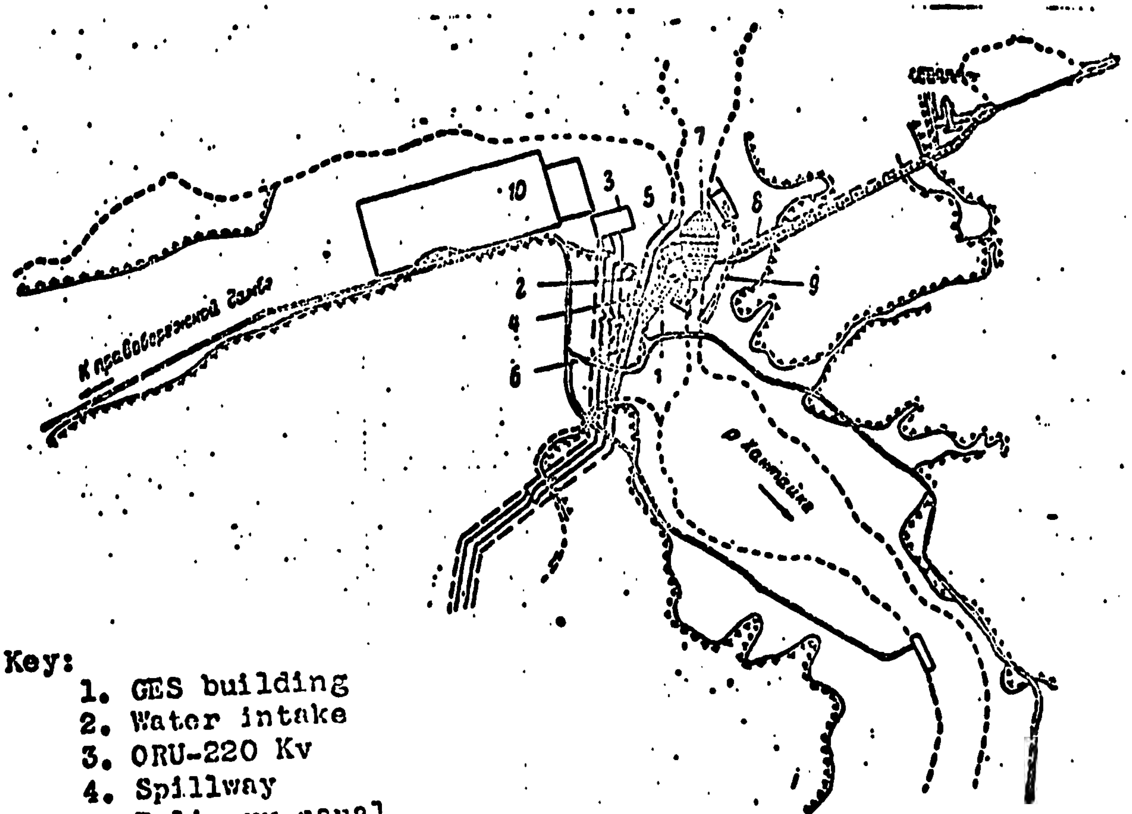
Work is now progressing on the second section of the intake heading, and on the preparation of the subsequent units for operation. It is planned to have all units in operation by 1972, and to completely finish the project by 1973.

The natural and climatic conditions of the Arctic have influenced a number of special features of the project and the basic approaches to the organization of its construction. An especially high discharge rate during the comparatively short spring and summer, and a comparatively low discharge rate during the rest of the year are the distinguishing characteristics of rivers in the far north. This made it necessary to take a basically new approach to building a by-pass for the river during construction. On rivers in the central belts or southern regions a protective cofferdam is usually built, and during construction the water passes through a diversion tunnel or a diversion canal all year around. On the Ust'-Khantayka GES, however, it was more economical to build a tunnel only capable of handling the average discharge rate. The spring-summer flood waters were handled by an overflow spillway through the main dam built up to the intermediate reservoir level.

This is the first such diversion built by Soviet water resources engineers.[4] This type of flood water bypass made it unnecessary to build the cofferdam 40 meters high. It only had to be 16-17 meters high. It was also not necessary to build a second section of a large diameter tunnel, a consid-

... flooded. A large part of the area to be flooded is occupied by tundra and swamp, and about 35,000 hectares of forest and brush. In view of the low quality of the wood, there are no plans to remove it.

The following are included in the main hydroelectric installation (see Figure 1): a rock fill dam on the main channel, earthfill dams on the left and right banks, a spillway, with delivery and spillway canals, a water intake, a penstock tunnel, an underground powerhouse with outlet canals, a control installation, and an ORU-220 Kv [220 kilovolt outdoor distribution system].



Key:

1. GES building
2. Water intake
3. ORU-220 Kv
4. Spillway
5. Delivery canal
6. Outlet canal
7. Channel dam
8. Left bank dam
9. Construction tunnel
10. Settlement for builders and operators

erable savings. The approach taken required a special low cofferdam for the entire installation. It was a log bunkhead, backfilled with rocky soil, and reinforced from above by a 3 meter reinforced concrete slab. Concrete was poured along the lower banks of this structure. In addition, special work was needed to protect the afterbay against washout. Flood waters passed through the incomplete dam twice, in the spring and summer of 1968 and 1969. In general, experience indicated that this approach to diversion during construction is very effective for rivers of the far north, convenient for work operations, and technically reliable.

In the north it is difficult to obtain enough impermeable soil, usually moraine and sandy loam of glacial origin, to prevent water filtration. This type of soil is quite widespread; however, the strata is not very thick. There are not many areas suitable for the organization of quarries for the extraction of large amounts of this material. What is more, this soil is very waterlogged, and as a rule unsuitable for immediate use as dam fill. Because of the very low temperatures it is also difficult to carry out quarry operations during the winter. These circumstances made the seasonal operation of the quarries necessary, and also dictated the following system of operations: a) the soil is excavated in the summer, hauled away and stacked in piles, b) the earth is kept in piles in order to dry it out to the desired moisture content. Electrical heaters help in maintaining proper temperatures. c) The soil is hauled from the piles and put on the dam all year around.

One should add that the high humidity during the Arctic summer makes for additional difficulties in working the quarry and in transporting the soil to the project. In addition, because of the insignificant thickness of the surface soil, which is removed just prior to working the quarry the primary material to be removed also freezes during the long, cold winter. This requires that it be worked layer by layer, as it thaws. Maintaining the fill schedule made it necessary to constantly use heaters, and to apply salt. Aircraft jet engines, which have been used beyond their guaranteed service lives are used as heaters.

Dam construction work was most intense at the end of the winter and in the spring months (March-May) which are most favorable for fill operations.

The fill operations technology, used previously at the Vilyuysk GES was also used in the construction of the Ust'-Khantayka project.[6]

The overall efficiency of dams made from local materials, the complexity of operations and their high cost in arctic conditions all indicate the necessity of looking for new approaches to antifiltration measures at dams, and new work methods. For example, the use of polymer materials for antifiltration purposes. The experiences of Khantaygesstroy /Khantayka Hydroelectric Station Construction Organization/ in the installation of the right bank cofferdam using sheets of polyetholyne affirms the advisability of using polymers for these purposes in the northern regions of the nation. It is only necessary to have the proper materials with a guaranteed service life.

Preparing the foundation for the intake head installations on the soft, permafrost ground was very difficult. The right bank of the dam of the Ust'-Khantayka GES is essential, because of the naturally low relief of the area. The surface layers are lake-swamp deposits, peat bogs and weak sandy loam, water-logged and permanently frozen. Beneath this layer are lake-glacial deposits, suitable for a dam base. The lake-swamp layer, about 6-8 meters thick, was removed. Working on the dam base on such soil is hindered by its absolute impassibility without a number of special measures (dumping rock on the roads, operating the excavators on platforms, and draining the area).

The lack of the necessary construction equipment and techniques ensuring smooth operation at low temperatures is one of the difficulties of construction in the north. This applies primarily to cranes and excavators. The equipment produced by our industry ensures their operation, at best, to minus 40-45 degrees C. However, in the north it is essential to have equipment guaranteed to operate at temperatured down to -60 degrees C.

Conclusions: The experiences gained in the construction and first period of the operation of the Ust'-Khantayka GES permit one to make the following conclusions:

1. The construction of a water project with a diversion through a partially built stone fill dam is technically feasible, economically advisable and reliable for rivers with discharge patterns characteristic of those in the northern regions

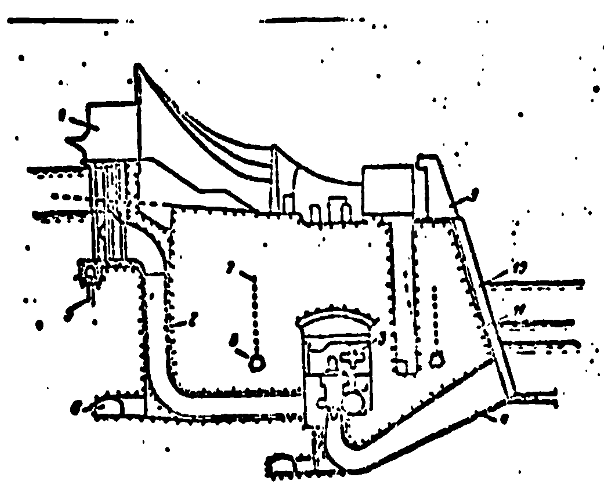
2. An underground type powerhouse is the most convenient for hydroelectric stations built in the north.

3. Present approaches to antifiltration measures are very laborious. It is therefore necessary to search for new technical solutions. Special attention should be given to the use of polymer materials, however, it is very necessary to take their service life into consideration.

4. One should note that there are now excavators with a bucket capacity in the 3-5 cubic meter range, or large capacity cranes capable of operating in the north. The presently produced E-1252BS and E-2505 excavators, and the K-162S, E-2508S, cranes, and other equipment are not productive enough for even the construction of average capacity hydroelectric stations.

5. The difficulty and complexity of building a dam on a soft base, of complex lake-swamp and lake glacial deposits, which are swampy, and part of which are permanently frozen makes it necessary to work out new technical approaches and to develop special earthmoving equipment suitable for operation under such conditions.

Figure 2 Powerhouse (Cutaway view)



Key:
1. Intake
2. Tunnel penstock
3. Powerhouse
4. Outlet
5. Grouting curtain
6. Additional tunnel for transport
7. Hole drilled for drainage purposes
8. Drainage tunnel encircling powerhouse
9. Repair gate
10. Aeration pipe
11. Special protective covering area

BRIEFS

GES UNDER CONSTRUCTION--Construction has started in conditions of permafrost of the most powerful GES in the northern USSR. It is on the River Kolyma. The dam will be 130 meters in height. Several powerful generating sets will be installed at the GES. Power will be supplied to gold prospectors, miners and the towns and villages of Magadan Oblast. The first turbine will be operational in 1973. Due to the cold climate the machine room will be encased in granite. A 150 km-long lake will appear near the future Kolyma GES. It is hoped that this will heat the climate somewhat. A cascade of power stations will eventually be built on the Kolyma, whose resources are over 4.5 million kw. [Moscow TASS International Service in Russian 1545 GMT 7 Jul 74 L]

STAT

HYDROTECHNICAL PROJECT -- Moscow, Izvestiya, Russian, 17 Feb 72, p 1

In the regions of eternal frost, on the Kolyma River which cuts through the east-west outlying districts of our country from the south right up to the Arctic Ocean, a majestic structure is beginning. A unique hydrotechnical structure will be constructed here, the Kolymskaya State Electric Power Plant. The design for it was worked out by the Leningrad branch of the Gidroproyekt Institute. V. Petrov, the chief engineer of the project, says, "For the first time in the world, under the most complicated natural and geological conditions, we are constructing a hydroelectric station with a rock dam whose height reaches 130 meters. A village for the construction workers has already been set up. Nearly 20,000 people will live in it.

New Hydro-Power Station to be Built in the Permafrost Zone of The Magadan Oblast'

The project of the Kolyma Hydro-Power Station, the first of its kind in the Magadan Oblast' has been approved. A rock dam 130 meters high will be built in this permafrost zone. The power generating machinery will be located in a "niche" inside a huge rock.

The Kolymagesstroy Administration is faced with the complex problem of performing a vast soil moving project, concrete and

it unnecessary to face the bypass channel with concrete. The machinery hall of the electric plant is original. It was hewn out of rock -- a huge handmade cave 140 meters long and 38 meters high. Seven 63,000 kilowatt hydraulic units were installed here.

Now work is in full swing at all sections of the construction site. The river flows in a newly built channel. The tunnel was covered and the reservoirs are beginning to be filled. An LEP-220 (Electric Power Transmission Line-220) was built to Noryl'sk. A powerful gantry crane was installed which controls two 280-ton gates. Most important of all -- the installation of the hydraulic unit is proceeding. The builders and installers joined in the competition in honor of the 24th Congress of the party, obligated themselves to complete the work a year ahead of schedule, place the first unit into operation in November of this year, and the second unit -- by the Power Engineering Workers' Day. The progress of the work indicates that this task will be accomplished.

A city for power workers is being erected along with the power plant. The future Snezhnogorsk will in no way be reminiscent of today's wooden village. Recently the Ministry of Power and Electrification of the USSR approved the project developed by the Krasnoyarsk branch of the "Giproprojekt" Institute for a housing complex which will spring up on the shore of the Khantayka River. It is called a city under one roof. Fifteen hundred people will live in it. The apartments will have from one to five rooms with all conveniences. Without going out of the building, the inhabitants of this unusual city will be able to stroll in a winter garden, go to a movie or library, take a swim in a pool, and utilize a multitude of personal and domestic services.

Strong, daring and stubborn men are needed to realize all that is planned. Here working days become acmes of achievement. This is said not for the sake of a pretty phrase. You talk to blasting workers and they will tell you about Vladimir Rossomakhin. He is not just a blasting worker, but also a mountain climber. He can blast at any height and as required. Excavation workers remember how their fellow worker, Nikolay Markov, saved his heavy machine when the water suddenly broke through the dike. The truck drivers -- about the unusual trip of Vladimir Shonov who, when driving over impassable roads to the icebound Khantayka ships, made a fantastic leap in his truck from a 20-meter cliff into a snow drift.

POLAR POWER PLANT UNDER CONSTRUCTION

[Article by Yu. Svintitskiy; Moscow, Sotsialisticheskaya Industriya, Russian, 11 November 1970, p 1]

Capricious, treacherous -- these are the epithets given to this subarctic Khantayka River. Ordinarily there is nothing unusual about it. It flows from Lake Khantayka through tundra as flat as a plate, and in only one place does it break through a comparatively small rocky rise. Only here, on the threshold, the "peaceful" Khantayka becomes wild. In flood stage, the water flow rises sharply at times to 12,000 cubic meters per second -- as much water as is carried by the Yenise River in the region of the Krasnoyarskaya GES.

The subarctic begins at the 68th parallel. The temperature in the winter is below -60°C, and in the summer -- up to +30°C. Underfoot the ground is either hard because of the permanent frost, or is an abyss of bottomless swamp. There are clouds of mosquitoes. The roads are impassable. These are the conditions under which is being built the Ust'--Khantayskaya GES, the most northern in the world. It is not just simply being built but, I might add, here the domestic experience of hydraulic construction is being enriched by finding new solutions.

The most fearless and daring challenge to the Khantayka builders was the decision to pass the flood stage waters through an unfinished stone fill dam. The swift current could have scattered the multiton rocks. But this time the decision was correct. As a result, it was unnecessary to build an additional bypass tunnel and a high river bed dike. Almost 5,000,000 rubles were saved.

The bypass channel through which the river was directed at certain times was built in a new way. Special cutting made

BRIEFS

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The Kolymagesstroy Administration is faced with the complex problem of performing a vast soil moving project, concrete and ferro-concrete work involving [illegible]

The Kolyma Power Generating Project

The Kolyma power generating station will have a substantial influence on the industrial development of the Magadan Oblast'. The station will be built in a permafrost area which is prone to seismic disturbances that could reach force seven. Personnel working on this project are accommodated at the settlement Sinegor'ye located at a distance of four kilometers from the construction site. A transshipment base was established at Uptar. Roads, various workshops and a plant for the production of ferro-concrete parts are being built.

The dam of the station will be of locally obtained rock fill and 130 meters in height. This material was selected because the site is far from roads. All loads for this project will be carried first to Nakhodka and then shipped by sea to Nagayevo, a distance in excess of two thousand kilometers. From Nagayevo the loads will be carried by truck over a distance of 500 kilometers along the Magadan route. Transportation costs for every ton of materials or equipment will amount to 50 roubles. In the case of concrete the cost will vary from 120 to 400 roubles per cubic meter. The dam will require several million tons of fill.

..The completion..

-

The completion of the project would be delayed by one year if this material had to be shipped from other places.

Power generating units will be placed in operation once the dam reaches half its final height. Specialists of the Metallurgical Plant "XXII Congress of the Communist Party of the Soviet Union" are designing diagonal turbines for the future station.

Engineers have already established the feasibility of building another four power generating stations on the river Kolyma.

Pravda
17 November 1972
Page 2 (Extracts)

CONSTRUCTION OF KOLYMA GES UNDERWAY IN MAGADANSKAYA OBLAST

[Excerpt from article by L. Margolin: "Sinegor'ye Will Be a City"; Moscow, Sovetskaya Torgovlya, Russian, 8 November 1971, p 4]

The telephone call was from Magadan. The words, which were repeated over and over by amplifiers, sounded hollow, as if an echo was rolling over the country.

"In Uptar, yes, in Uptar our builders have completed a new school... They have extended the road to the dam site. Aluminum prefabricated dwellings have gone up at Sinegor'ye. We will be opening a real dining hall, not a temporary one, in November... And then a little later -- a store with eight employees... I repeat: with eight employees.

The call was a reminder of my recent trip. Together with workers from the worker supply administration of the Severovostokzoloto Association we were bouncing along a swampy area covered with frost in our wind-blown little GAZ, looking over the vast expanses for the most reliable reference points -- the wooden supports of the future electric power line. Somewhere dump trucks were rumbling along with great difficulty. They were bringing in bed rock for the future road, covering the permafrost with a thick layer of earth: since the road must withstand the hot Kolyma summer.

We were hurrying. Back at Uptar at the hydraulic workers' base, some 400 kilometers from these places, Aleksandr Alekseyevich Sarev, the chief engineer of the project, promised to let us see the first, can you imagine, the first explosion at the site of the future dam. We were late. Very late. The reverberations of the explosion were felt just at the time we arrived at the road sign whose plywood arrow pointed the way to Sinegor'ye. This is what they decided to call the future city of the builders of the Kolyma GES, the erection of which was specified in the directives of the 24th Party Congress.

Then later we travelled along Nevskiy Prospect. Thus, jokingly this is the name the Leningrad hydraulic surveyors gave to the only street of their town which was situated between several houses along the bank of the Kolyma.

[illegible] residences
[illegible] the call [illegible] which tractor-trucks had dragged to the site selected for the town, [illegible] which tractor-trucks had dragged to the site selected for the town, [illegible] seemingly forming the blocks of the future city. At last the much used term "future" was being replaced by actual. It was taking shape before one's eyes. There was the road, the explosion in the quarry, and the first dining hall with a simple menu for communal serving. The realness of this future town lies in the everyday, but each time very exciting, work in the creation of what will soon become a huge construction project and city, and about which they will say: "You remember..." And the entries in my journalist's notebook will also become a page in the history created here.

The Leningrad hydraulic surveyers arrived here first late in the fall of 1967. They were supposed to select the ideal spot for placing the future dam. It will rise 130 meters at the spot where the small Bakhapcha River merges with the Kolyma. Here Aleksandr Yefimov, a Communist and party group organizer of the drilling sector, dug the first exploratory tunnel. The first real trip along the sloping cliffs of the Kolyma was completed in 16 degree weather by bulldozer operator Mullanur Gazizullin, winner of the Order of Lenin. And later came the legendary trip of the column of equipment operators, who over nearly impassable roads and in freezing weather, and the birds froze in mid-air, covered a distance of 3,500 kilometers. From the city of Chernyshevskiy to the hydraulic engineers' base -- to the village of Debin. Thus, those who were to do the work, the workers and specialists who were responsible for the erection of the unique Vilyuy GES, arrived at Kolyma next. Among them were the Glushak brothers who recently were awarded orders. The experience of putting up this station will help resolve the task which until recently seemed impossible: to build a large impressive station such as Kolyma in a permafrost area, where there are biting frosts and tornado winds.

And there is still more. This construction project is being started in a region which freight shipments must cross the whole country by rail, then go by steamship to Nagayev Bay, and from there are transferred to vehicles which have to travel over 500 kilometers along the Kolyma and then from the village of Debin several dozen more kilometers along roads which have only recently been completed.

"There are two views on how to build Sinegor'ye: whether to the bring the people to the construction site on a temporary basis, or to have them set up permanent residency," the chief of construction Yu. I. Frishter told us. He is young, as are many of his comrades, and worked at Divnogorsk. The Kolyma is his first independent project.

"We feel that," he continued, "productive work and shortened completion periods to a large degree depend on the conditions under which the builders live and work. Existence in northern regions requires the best in construction, and it is needed now, not sometime in the future."

[illegible] of the project is [illegible] to [illegible] the notorious concept of "[illegible]," which usually involves an uncomfortable nomadic existence, difficulties in supply, and a disregard for the needs of the people. In the Kolyma the "[illegible]" lies in the goal itself, the unusualness of the task facing us. And so it was decided to make things a little more refined. Even in Moscow they advised me to visit the base of the construction workers at Uptar which is located at the very beginning of the Kolyma trail. Here are sturdy two-story log houses, well-stocked stores, a hotel, dining area, and school which they put up in one summer... The engineer of the production-technical section Nikolay [illegible] showed me his living area: a separate one-room apartment, all the necessary comforts, including hot water. And this, if you please, before one project has been started.

The chief engineer of construction A. A. [illegible]rov suggested we take a walk through Sinegor'ye, over its streets and squares, by means of the blueprints. The builders will provide the Far Eastern people with a unique hydroelectric station of the underground type here, the largest of this type built in the North, as well as a large number of production enterprises. There will be about 16,000 people in Sinegor'ye by the time the first units are in operation. There will be schools, movie theaters, a club, eating places, stores, warehouses, hothouses, and service facilities.

The workers of the URS [Administration of Workers' Supply] confronted the chief engineer of the project: so you are planning a public trade center. Where is the best place to put it? It is necessary to examine all possibilities quickly. The construction of several stores has been planned. Self-service equipment ought to be ordered. And in general it is important at the very beginning, that those who build these facilities and those who work in them work out the general strategy and procedures for development of the sphere of operation.

But there are problems and they are not small. Some of them are the result of the severe conditions here. In order to set up a fair for the surveyors, the chief of the department Kh. A. Rakhinshteyn had to order a helicopter: until this fall there were no other ways of reaching the dam site than by air. Rakhinshteyn has been in the Kolyma area many, many years, and recently he was awarded the honorary title "Veteran of Labor in Magadanskaya Oblast".

"I must admit: there is no construction project like our GES anywhere in the North," he said.

The Kolyma GES is the primary construction project of the current Five-Year Plan in Magadanskaya Oblast. And for the workers' supply administration of Severovostokzoloto it is only one of many trade projects. They are in a hurry at the administration, having done away with the trade office in the neighboring town. And having abolished it, they now wonder: who will now serve the project to which thousands of workers will soon be coming? It is obvious that the efforts of one trade department can not handle such a task.

[illegible] GES TO BE BUILT -- Vil'nyus, Sovetskaya Litva, 17 Aug 71, p 1

On the banks of the powerful northern Kolyma River, at the 62nd parallel, a settlement has arisen with the poetic name of Sinegor'ye. People have come here from all corners of our country. Among them Ukraine, Belorussia, Kazakhstan, Georgia, Latvia and Kirgizia are represented. They have come to the far-away and stern Kolyma River to build the largest GES /Hydroelectric Power Plant/ in the far Northeast. What will the Kolymskaya GES be like? This question by a TASS correspondent was answered by Yu. I. Frisher, chief of the new construction site. "The Magadanskaya Oblast is truly called the 'treasure chest' of the country. It has the richest fields of silver, tin and other valuable and useful ores. Further development of the mining industry in this territory requires much electric power. Therefore, it was decided to build a powerful plant on the Kolyma River. It will give life to new cities, settlements and mines. Several years will pass and a stone fill dam 130 meters high will divide the Kolyma forming a 14 billion cubic meter reservoir. The main building of the plant will be 'hidden' deeply underground in the rock. This will make it possible to build year-round without fear of the 60 degree cold. The first stage of the Kolymskaya GES will be placed in operation in 1976."

REPORT FROM KOLYMA GES CONSTRUCTION SITE

[Interview with Professor G. K. Sukhanov; Moscow, Pravda, Russian, 30 November 1970, p 6]

A state commission has selected the location for the Kolyma hydroelectric power plant. Here is what was told to special Pravda correspondent, V. Kotlyarenko, by a member of this commission who recently returned from the construction site, deputy chief engineer of the "Gidroproyekt" Institute, Hero of Socialist Labor, Laureate of Lenin's prize, professor G. K. Sukhanov.

Professor G. K. Sukhanov started by saying that the Scientific Engineering Soviet of the Ministry of Power and Electrification USSR approved the first stage of the engineering project of the Kolymskaya GES developed by the Leningrad branch of our institute. The project plan is to build the hydroelectric plant in the middle of the Kolyma River. The dam will be stone-fill, 130 meters high. Several powerful units will be installed at the plant. It will produce billions of kilowatt-hours of cheap electric power.

Question: Why is the Kolymskaya GES being built?

Answer: The Kolymskiy Kray has incalculable natural resources. Its gold mines are world famous. There are a great number of other "representatives" from Mendeleyev's Table. However, the mining of useful minerals has not been developed everywhere in Kolyma according to the last word in engineering, so to speak. Cheap electric power is the Archimedean lever by which the transformation of this rugged region can be accelerated.

The mining industry of the region will be radically re-equipped. Many industrial processes will be mechanized and

automated with the help of electric power. The productive forces of this region will develop much faster. The new hydroelectric power plant will light a real electric sun over the Kolyma.

The nature of electric power consumption in this region favors maximum satisfaction of industrial, cultural and domestic service requirements. Its peculiarity is such that the industrial and public requirements are not only not in conflict, but on the contrary, aid each other. In the summer when there is intensive mining of useful minerals, placer and other mines have plenty of power. By the way, this availability of power will be helped by the Kolyma River itself which, during the summer, has more water. In the winter when the rate of mining is reduced, plenty of power will be available to the public and to cultural-consumer service enterprises. Heat for houses will be available during the severest cold, and the darkness of the long northern nights will be banished.

Question: Isn't it difficult to build a hydroelectric power plant under the stern conditions in the Kolymskiy Kray?

Answer: Yes. The conditions under which builders have to work are not easy: very low temperatures, stormy winds, permanent frost, and summer floods of the Kolyma River. It was decided to build the plant at an accelerated rate. An arrangement was proposed to start operation of the GES even before building the basic dam -- on the pressure created by a partially built upper wedge of the dam. This will speed up the installation of the first units by 2-3 years. The plant will be built underground. Its machinery hall will be cut into rock. This will make it possible to provide accelerated rates of construction. Sheltered construction workers will be able to keep to the schedule with greater assurance, in spite of the great cold and wind. Another problem has been solved: how to pass the high flood waters of the Kolyma through the comparatively narrow section of the hydraulic center. A multichannel reinforced concrete pipe will be built on the lower terrace of the shore to which the flood waters will be directed. Research is being conducted on the solution of another problem, perhaps the most difficult. Measures must be developed that would make it possible, at such a high pressure head (over 100 meters), to create a reliable antifiltration screen at the bottom of the dam under conditions of permanent frost.

Original solutions and innovations will not only reduce the construction time. They will make it possible to reduce the cost of the hydraulic center by dozens of millions of rubles.

Question: What is the construction schedule?

Answer: It is planned to start basic installations next year. The construction work will be done by "Kolymagastroy" the new "offspring" organization of the "Vilyuygesstroy." Even now, however, preliminary work is going full speed ahead. A transfer base is being built at Magadan, along with warehouses for receiving freight as well as living quarters for the construction workers. From here freight will be sent to the construction site by trucks furnished by the "Kolymaesstroy." The car pool will have 200 cars of various makes. A village has already been built 47 kilometers from Magadan near the road to the construction site. Prefabricated houses designed by members of our institute have already been brought here. The construction workers live in these houses, and later on workers on the transfer base and truck drivers will live in them. A graded road for vehicular traffic 45 kilometers long is being built from the village of Debin to the site of the dam. Ten kilometers of road have already been completed. Poles are being installed from Debin for an electrical transmission line. The building of a bridge across the Kolyma will start any day now since the road is on one side of the river, and the construction site is on the other side. Port installations and piers will be built at Nagayen Bay in order to receive an uninterrupted stream of freight shipped by sea.

It is impossible not to be surprised at the enthusiasm and true heroism of the people working here. Many probably already know that last winter a column of mechanics of the "Vilyuygesstroy" movedfrom Chernyshevskiy in the region of the building of the Vilyuyskaya GES to the shores of the Kolyma. The column consisted of modern powerful equipment so necessary to the builders of the future Kolymskaya GES -- giant dump trucks, powerful bulldozers, excavators, and tractors. Pushing through on difficult roads, the column traveled 3,500 kilometers and arrived safely at the village of Debin.

Now, when the building has essentially started, it is impossible not to recall the pioneers -- the explorers of the "Gidroproyekt." They made the first "landing" on uninhabited tundra four kilometers from the site, and were able to start quickly the study of the engineering geological conditions. Our explorers, under the guidance of Nikolay Yemel'yanovich Karpov, did a great deal of topographic-geodesic, hydrological, and engineering-geological work directly at the site of the future dam, as well as in the area of the village for the construction workers and the construction base. In selecting the site for the hydroelectric power plant, data obtained by our explorers in a short time, played a decisive role.